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Davis et al.

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(54) **ELECTRICAL CONNECTOR AND PANEL ASSEMBLY**

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(73) Assignee: **The Whitaker Corporation**, Wilmington, DE (US)

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(22) Filed: **Feb. 8, 1999**

(51) **Int. Cl.**[7] **H01R 29/00**
(52) **U.S. Cl.** **439/188**; 439/353; 439/660; 200/51.09
(58) **Field of Search** 439/660, 637, 439/862, 65, 357, 668, 344, 188; 200/50.19

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Drawings from Case No. 17277, Ser. No. 09/245,750, Filed Feb. 8, 1999, Related Application, 9 sheets.

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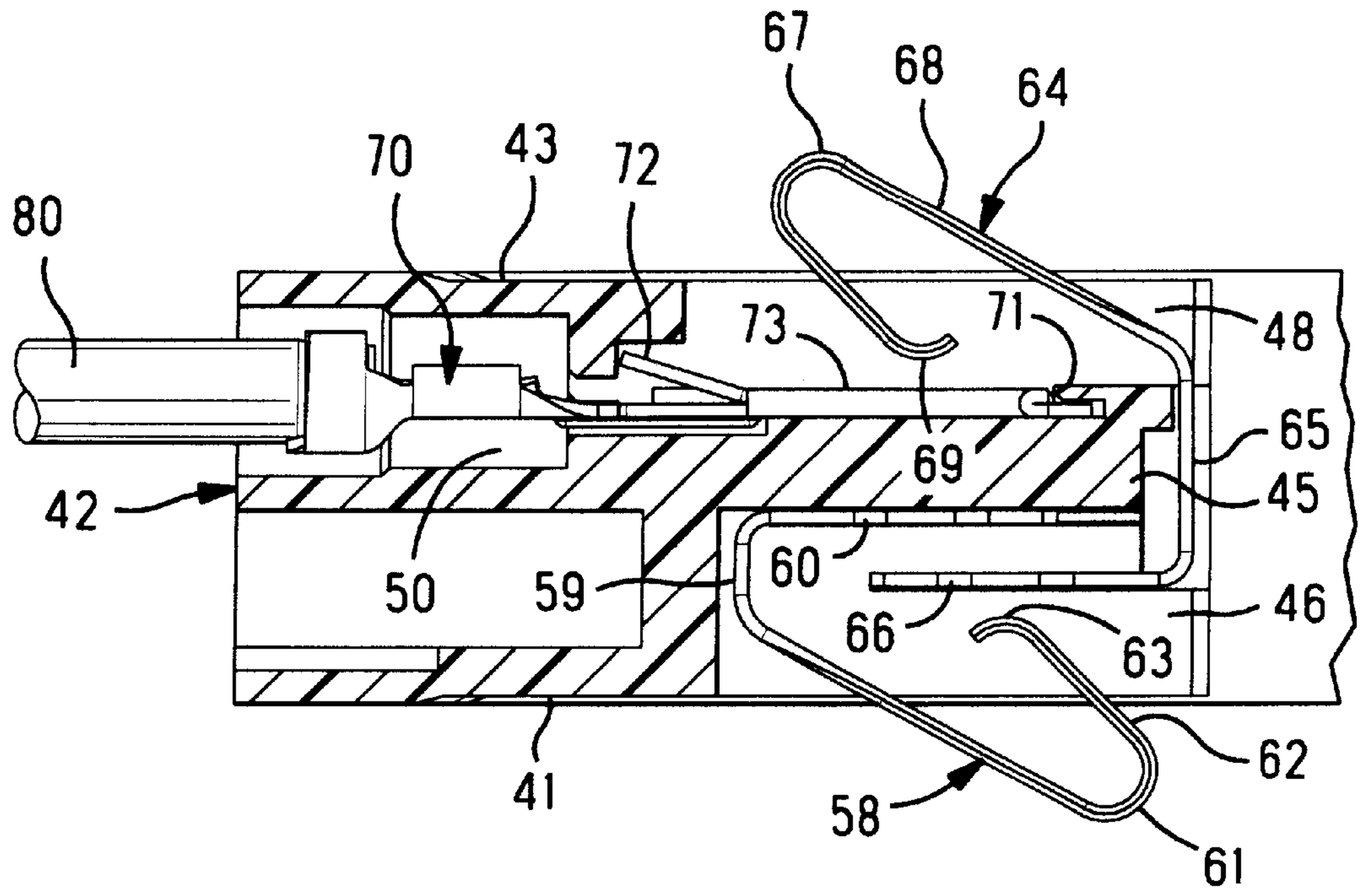
Primary Examiner—Renee Luebke
Assistant Examiner—Briggitte R. Hammond

(57) **ABSTRACT**

An electrical interlock connector (**40**) includes an insulating housing (**42**) containing at least one terminal-receiving cavity (**46**) with an electrical terminal (**58**) disposed therein and a first circuit member (**70**) connected to a power source and attached to the housing (**42**). The terminal (**58**) includes a spring section (**62**) having an outer connecting portion (**61**) adapted to be electrically connected to an electrical unit (**28**). The outer connecting portion (**61**) resiliently extends outwardly of a first housing surface (**41**) to an open position wherein the terminal (**58**) and the first circuit member (**70**) are electrically disconnected. The outer connecting portion (**61**) is movable into the cavity (**46**) to a closed position by a first portion (**26**) of the apparatus (**20**) upon mounting the connector against first and second portions (**26, 36**) of the apparatus. The connector (**40**) has a section (**69**) along a second housing surface (**43**) that engages the second apparatus portion (**36**), whereby an inner connecting portion (**63**) of the spring section (**62**) is at least in electrical connection with the first circuit member (**70**) only when the connector (**40**) is against the first and second apparatus portions (**26, 36**) and the terminal (**46**) is in its closed position.

40 Claims, 14 Drawing Sheets



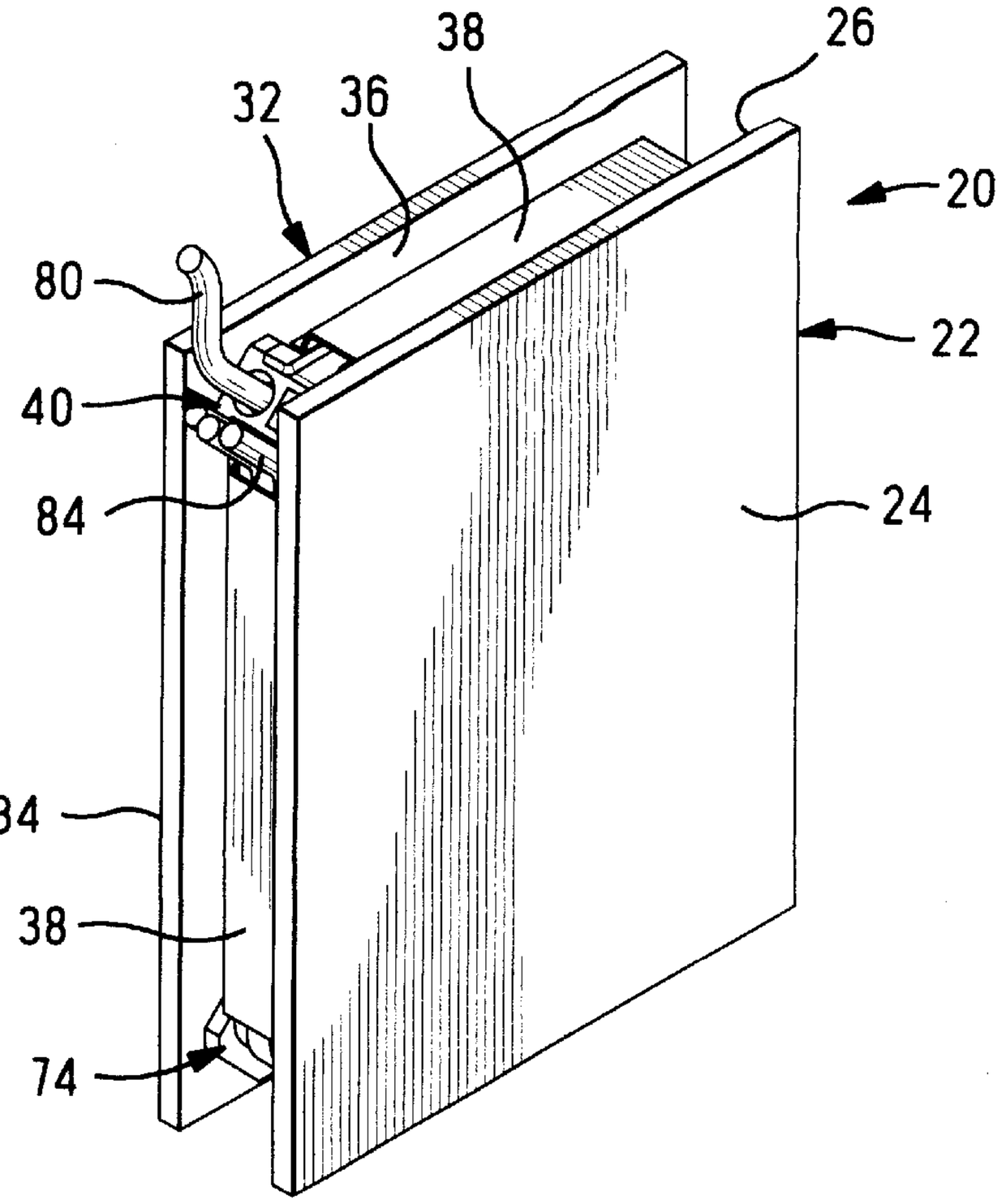

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FIG. 1

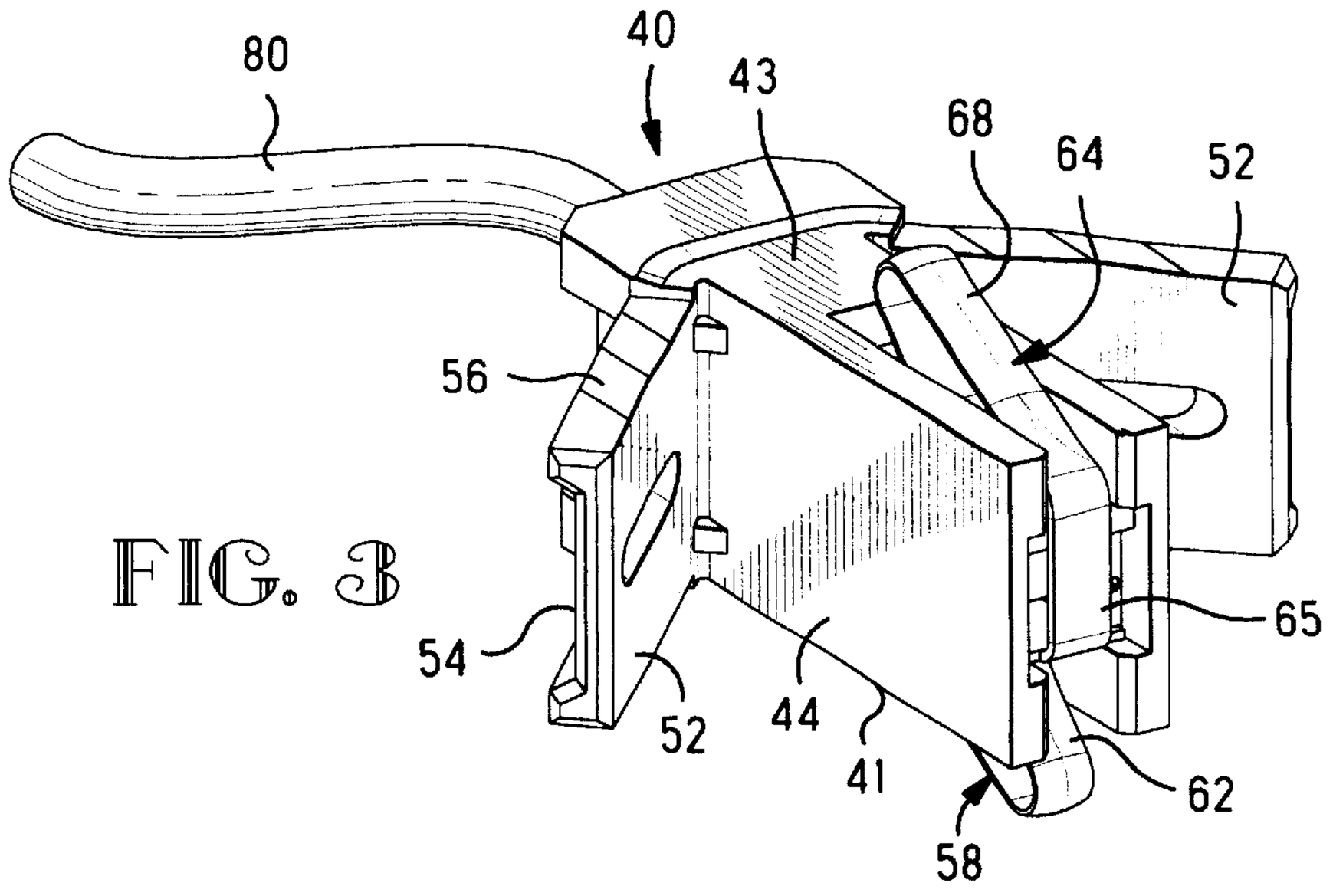
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FIG. 3

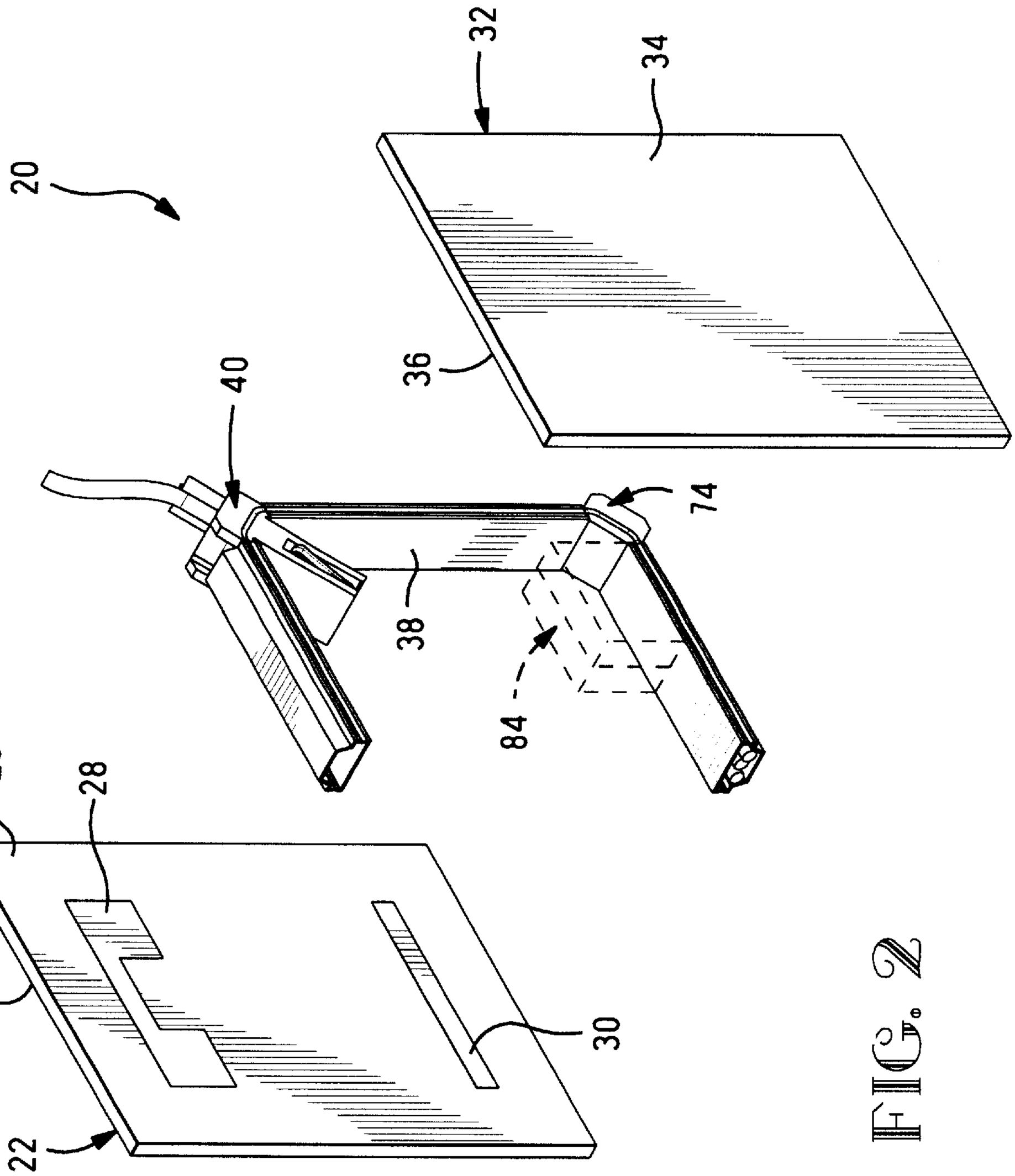

FIG. 2

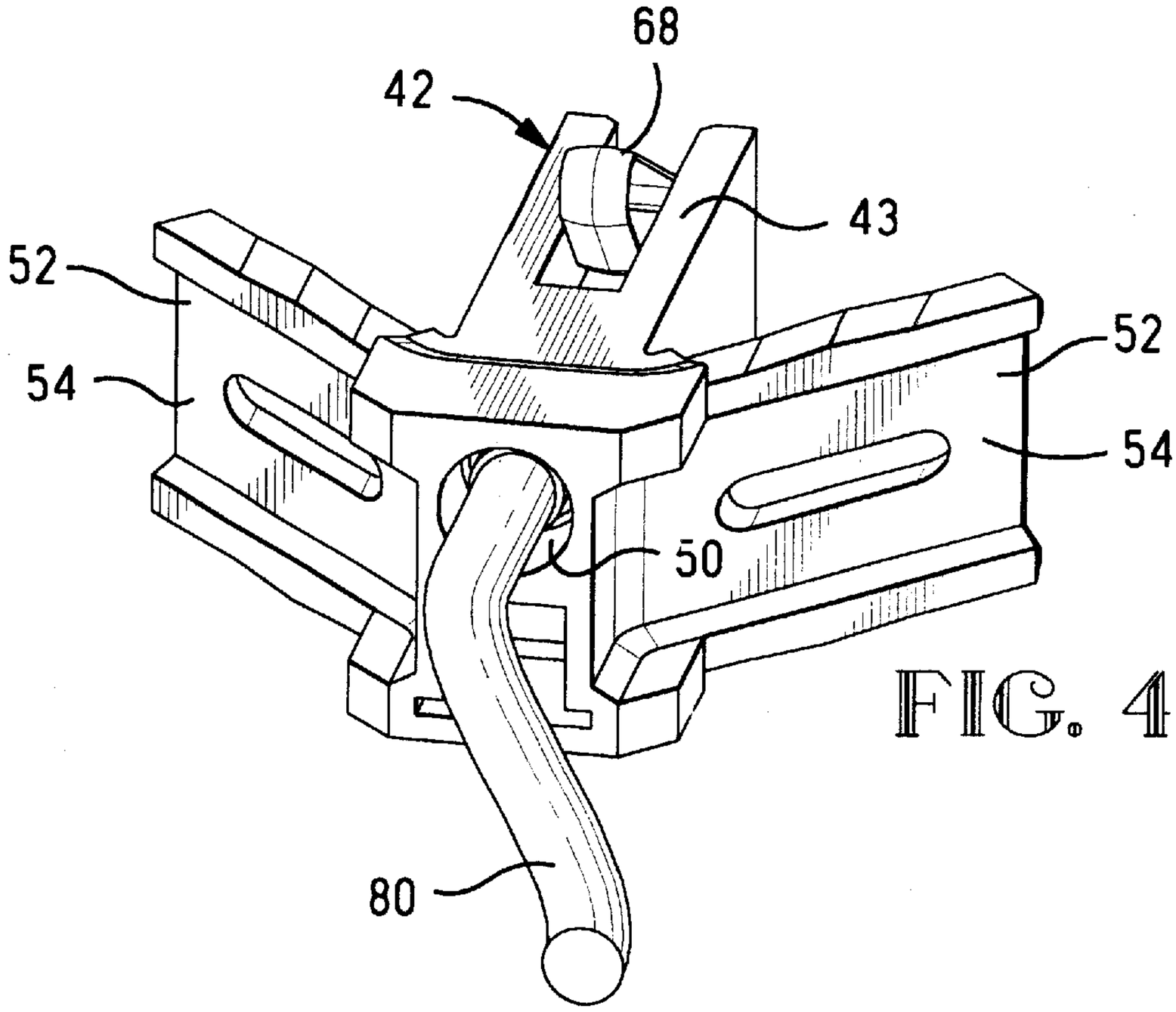
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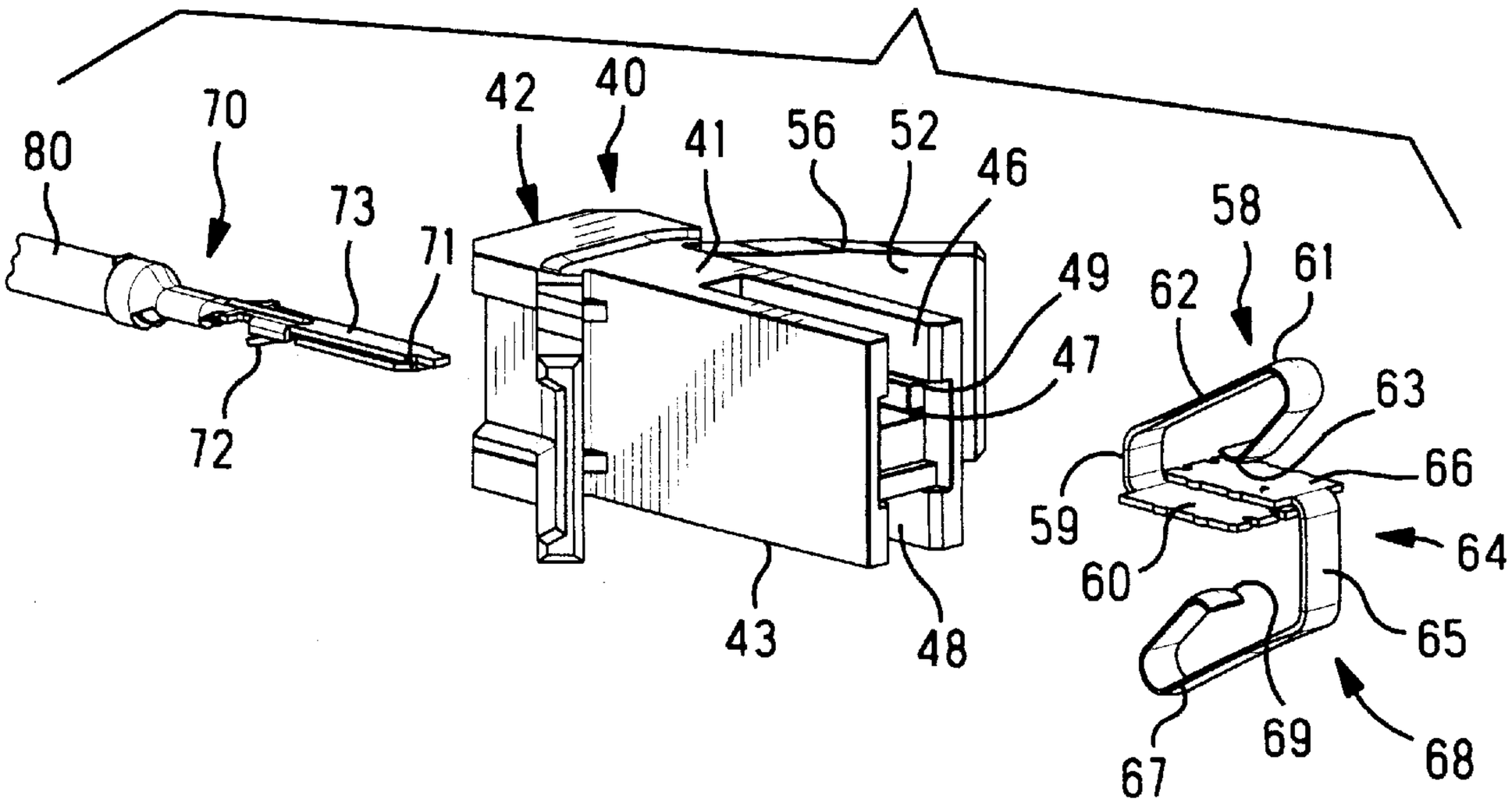
FIG. 4

FIG. 5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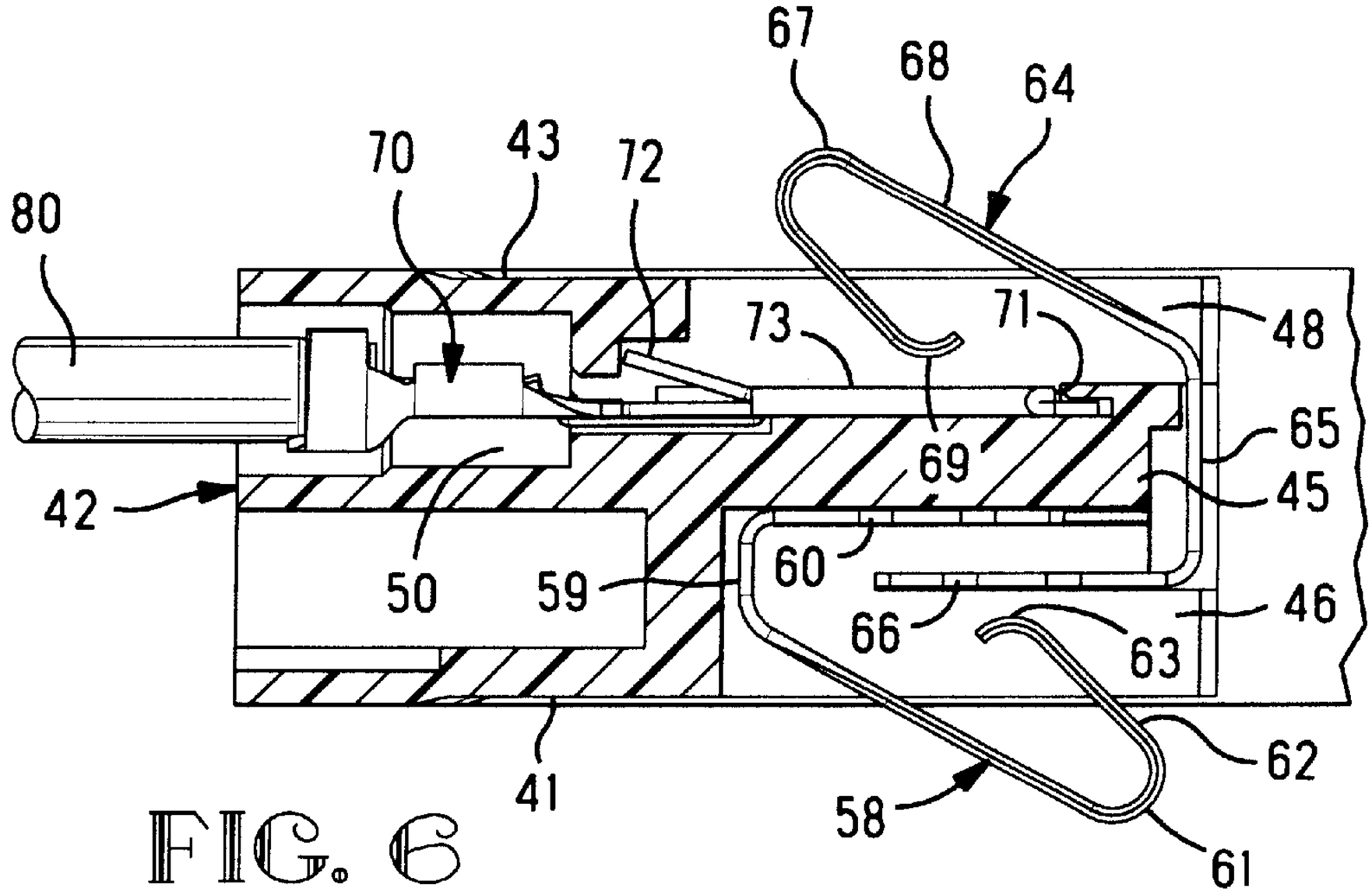
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FIG. 6

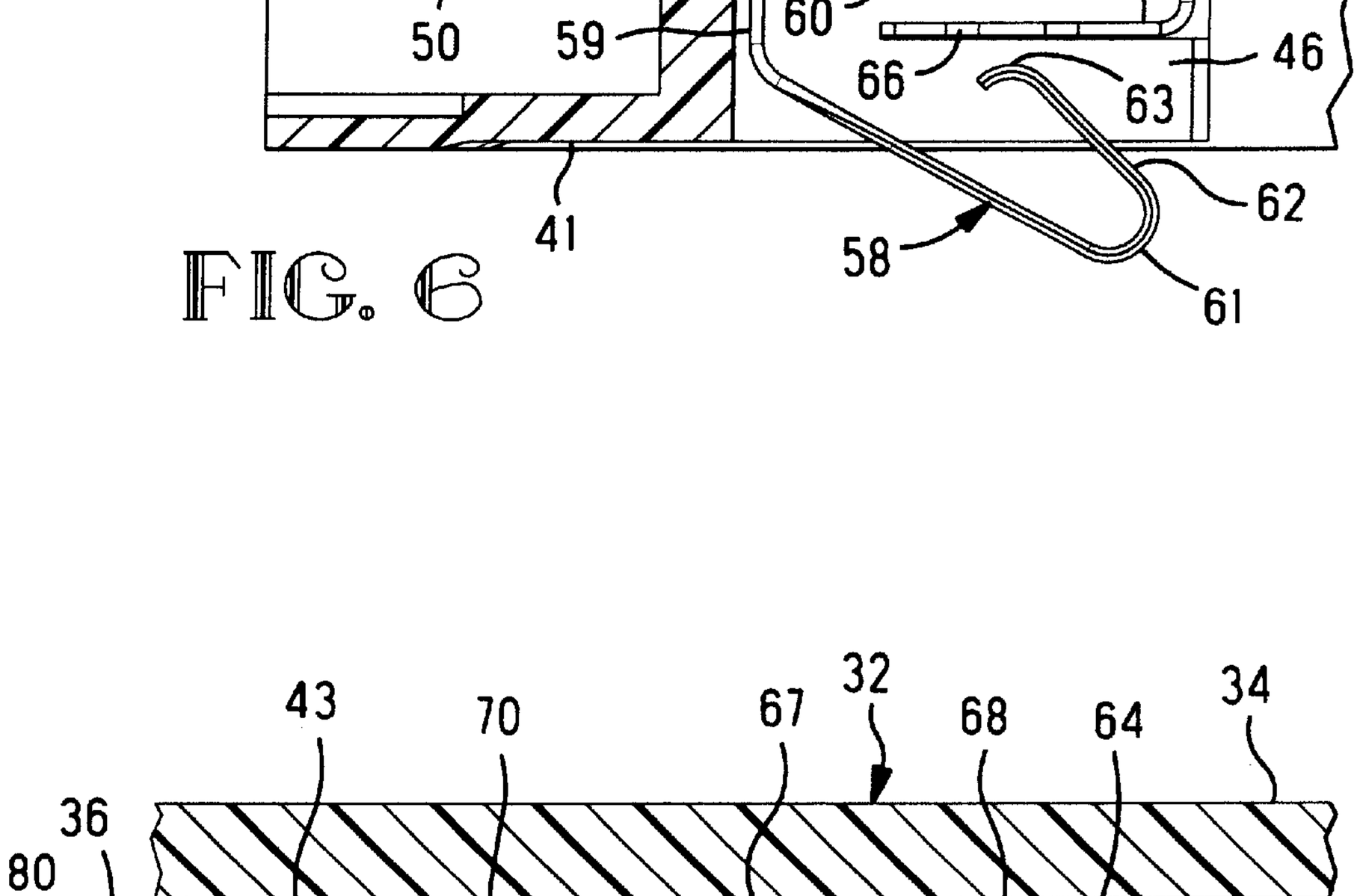
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FIG. 7

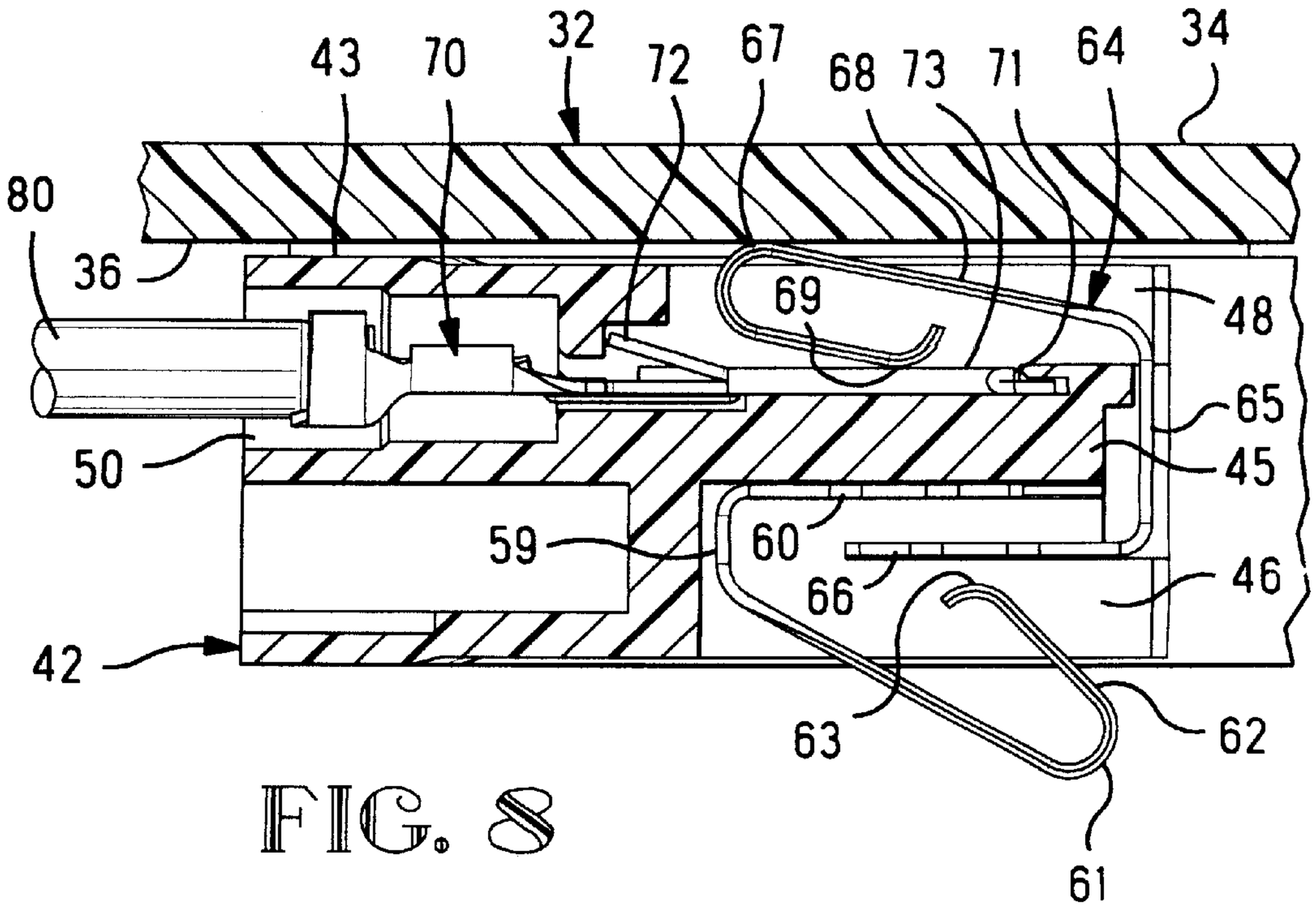
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FIG. 8

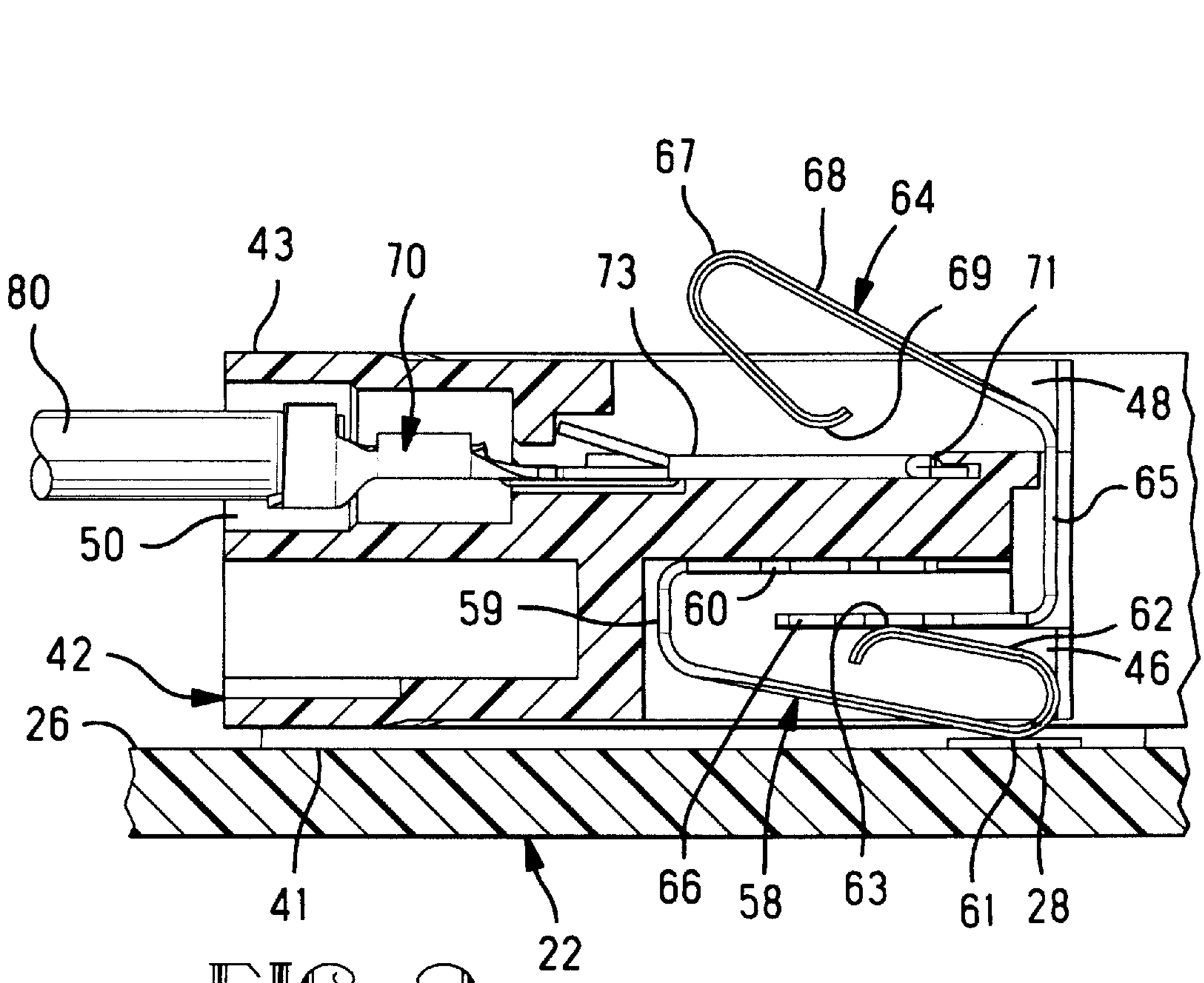
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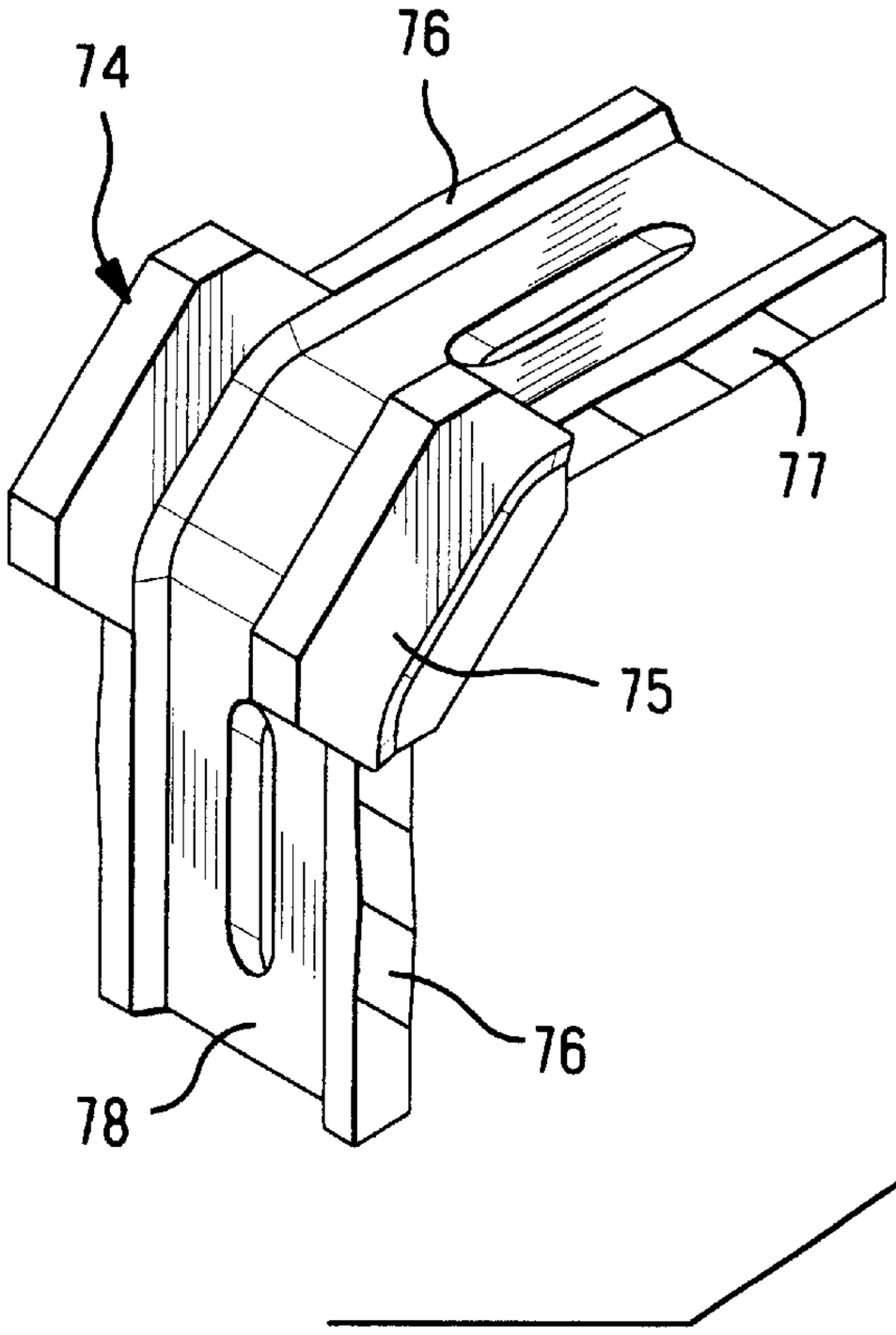
FIG. 9



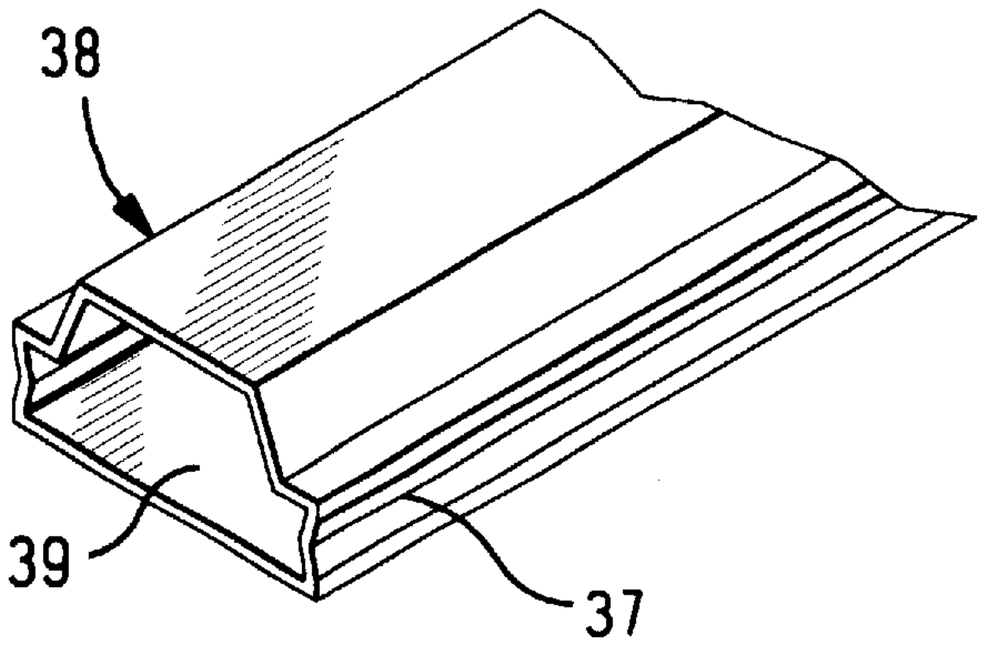
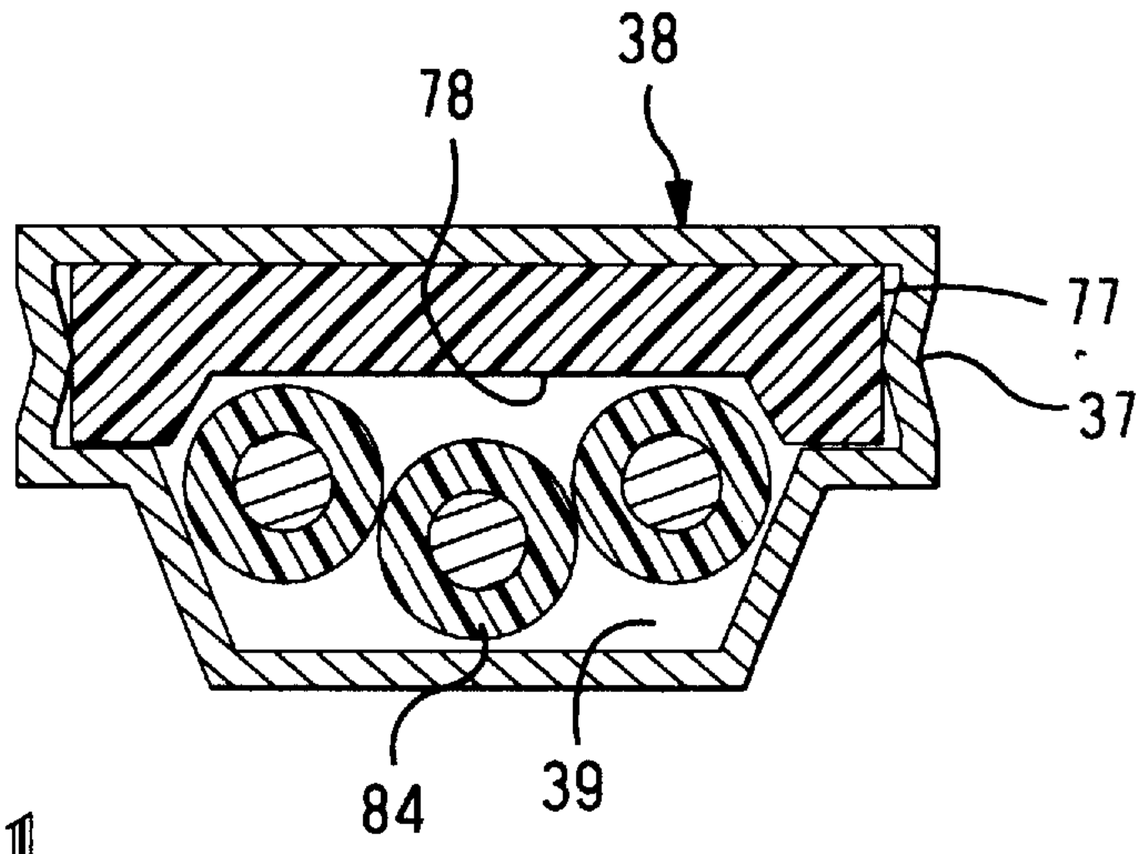


FIG. 10



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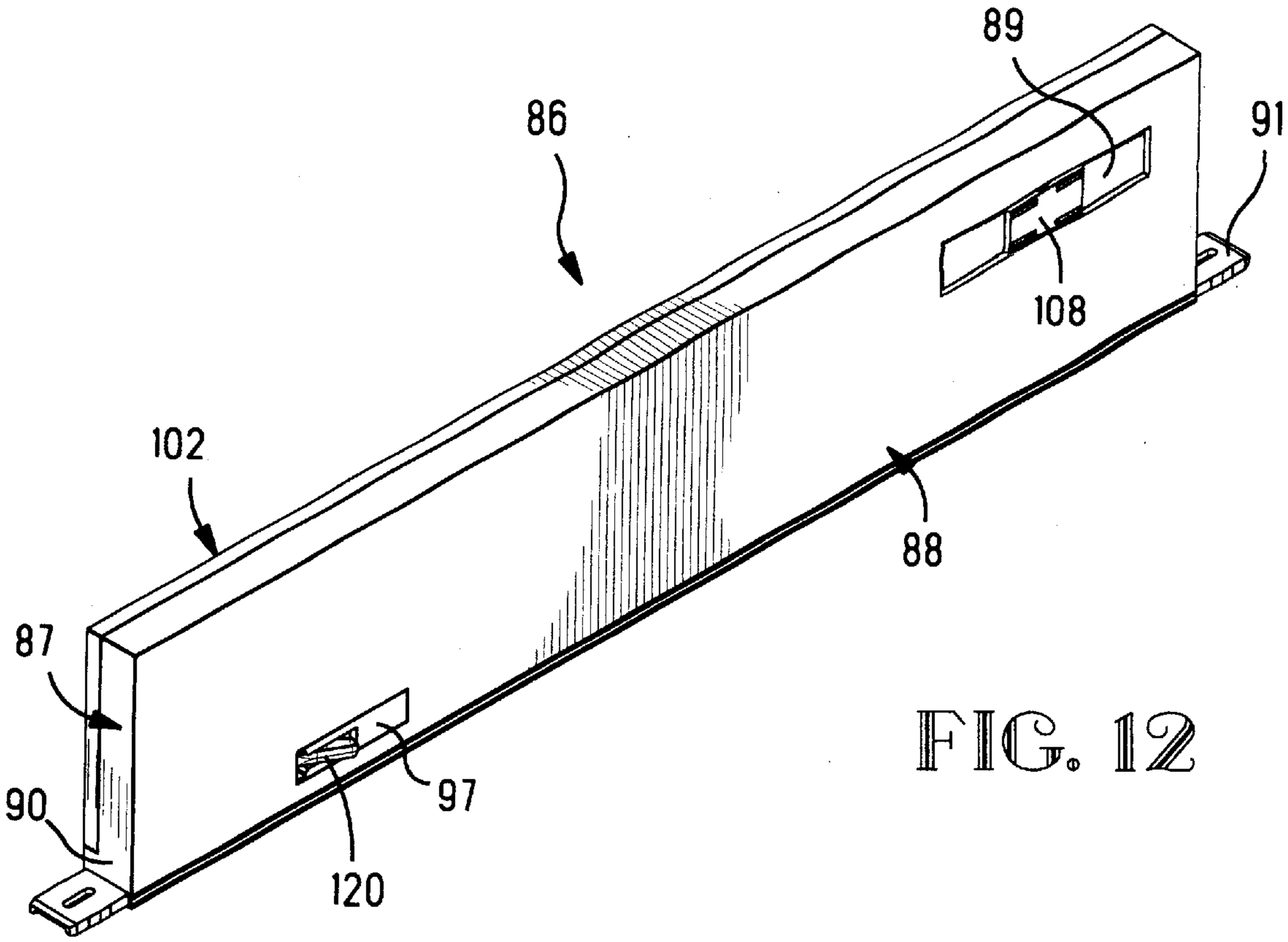
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FIG. 12

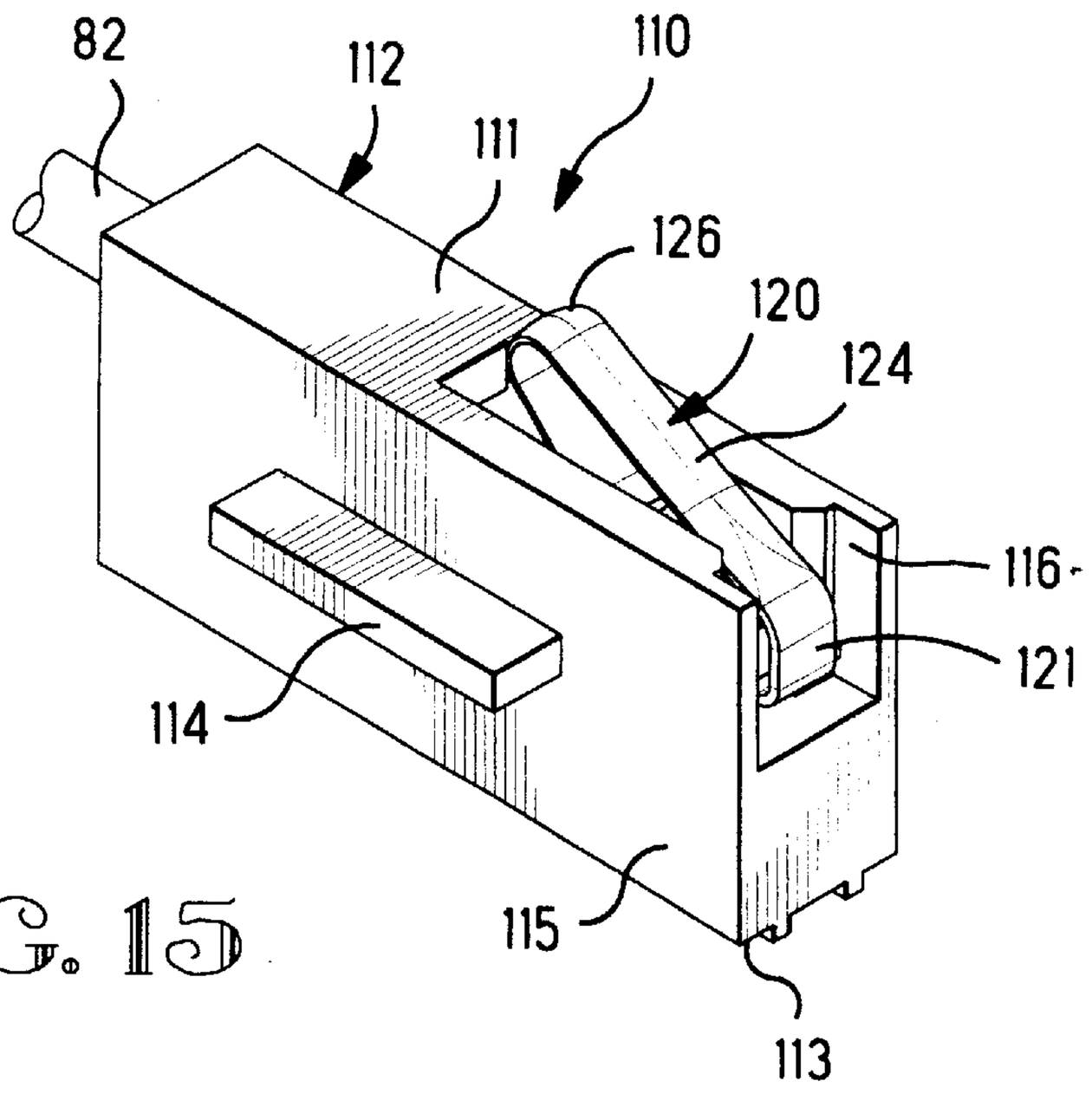
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FIG. 15

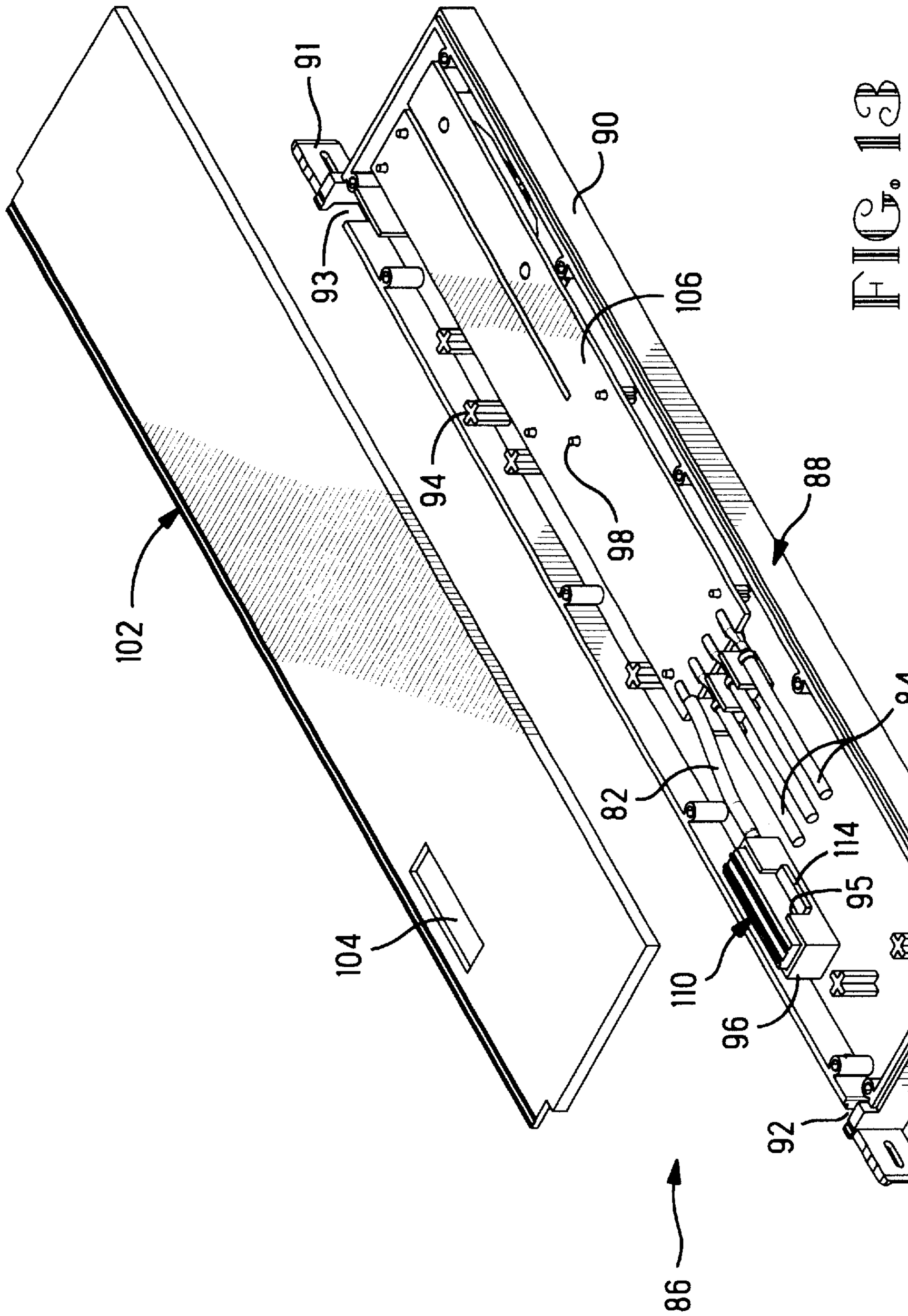
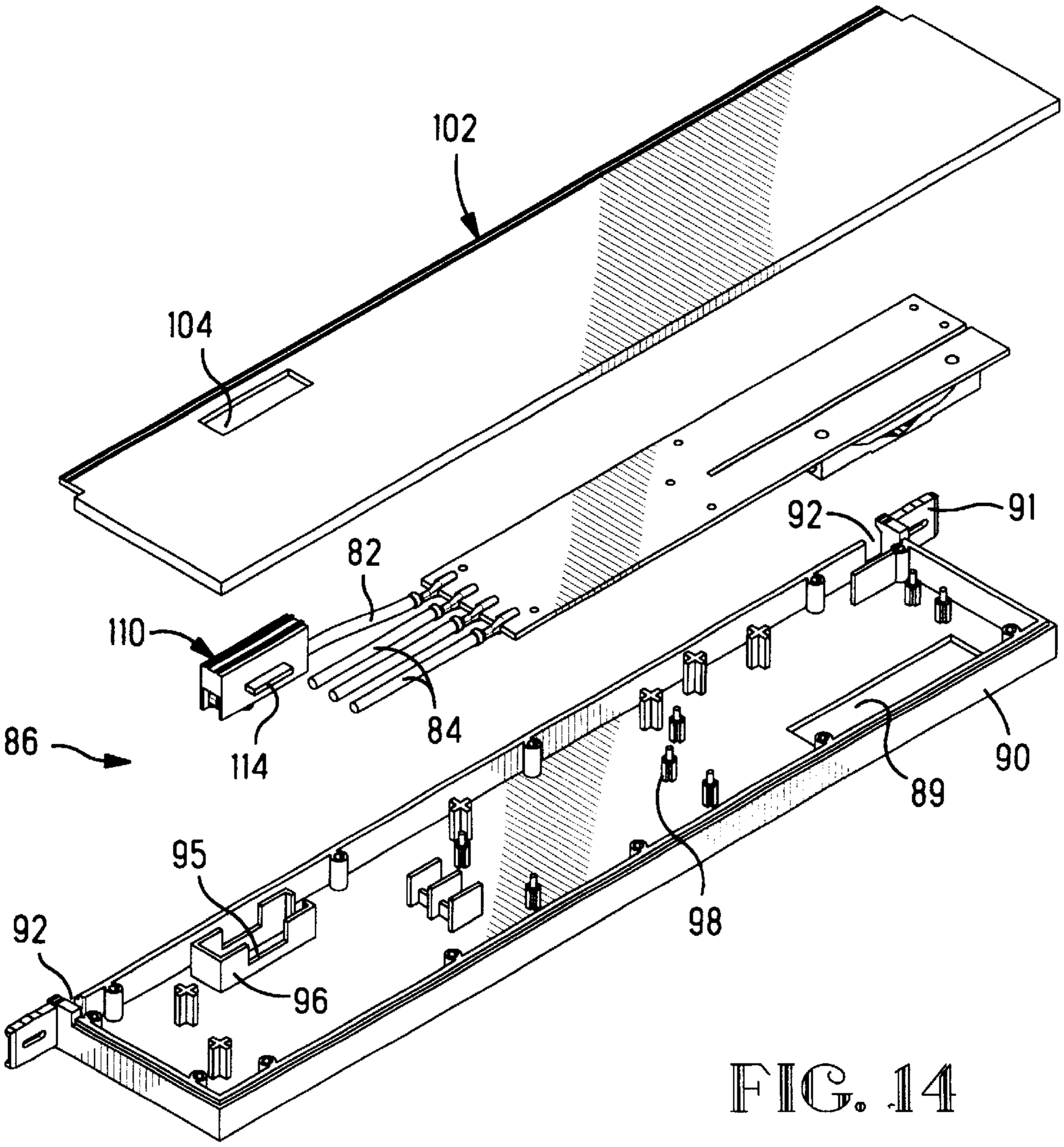


FIG. 13B



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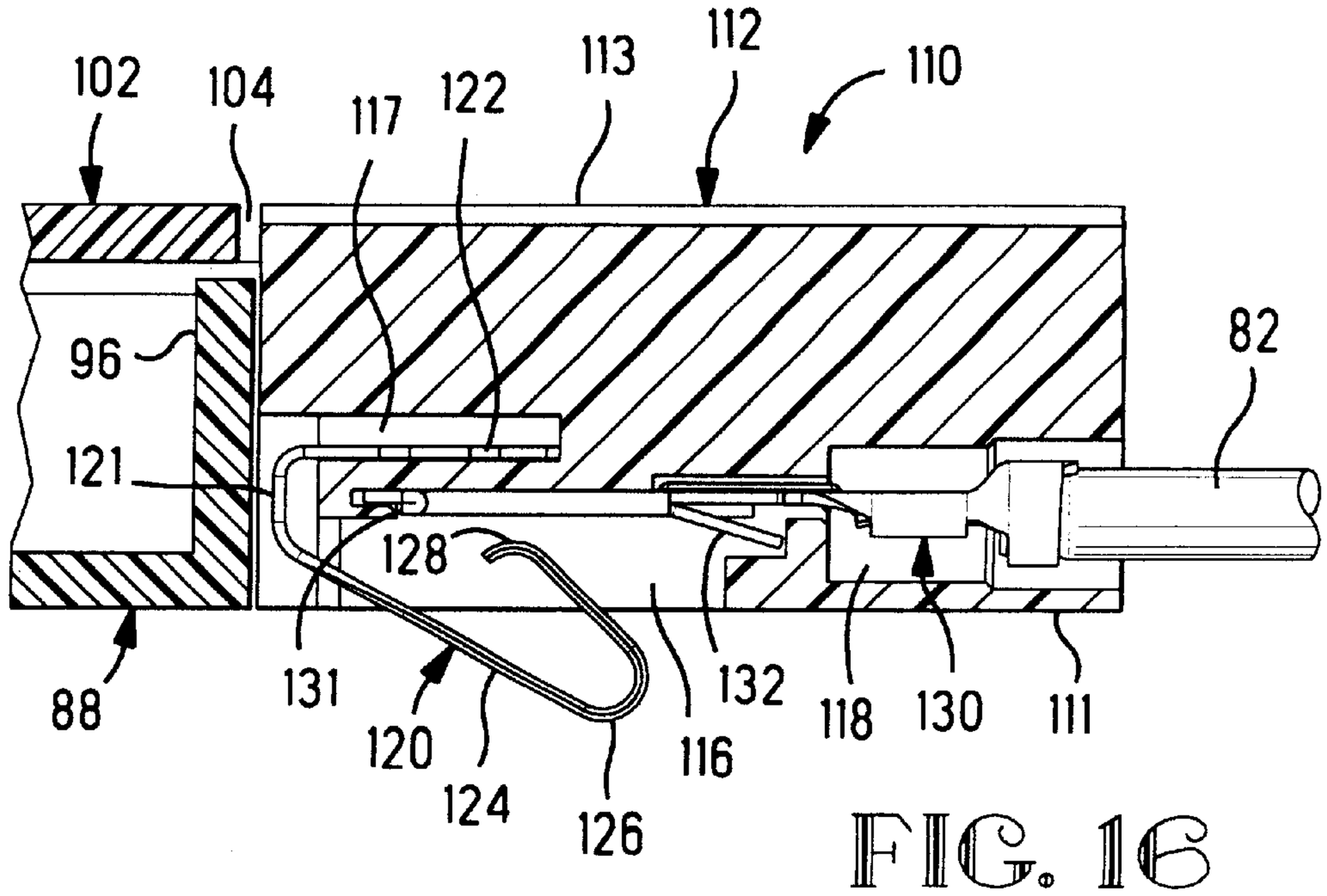
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FIG. 16

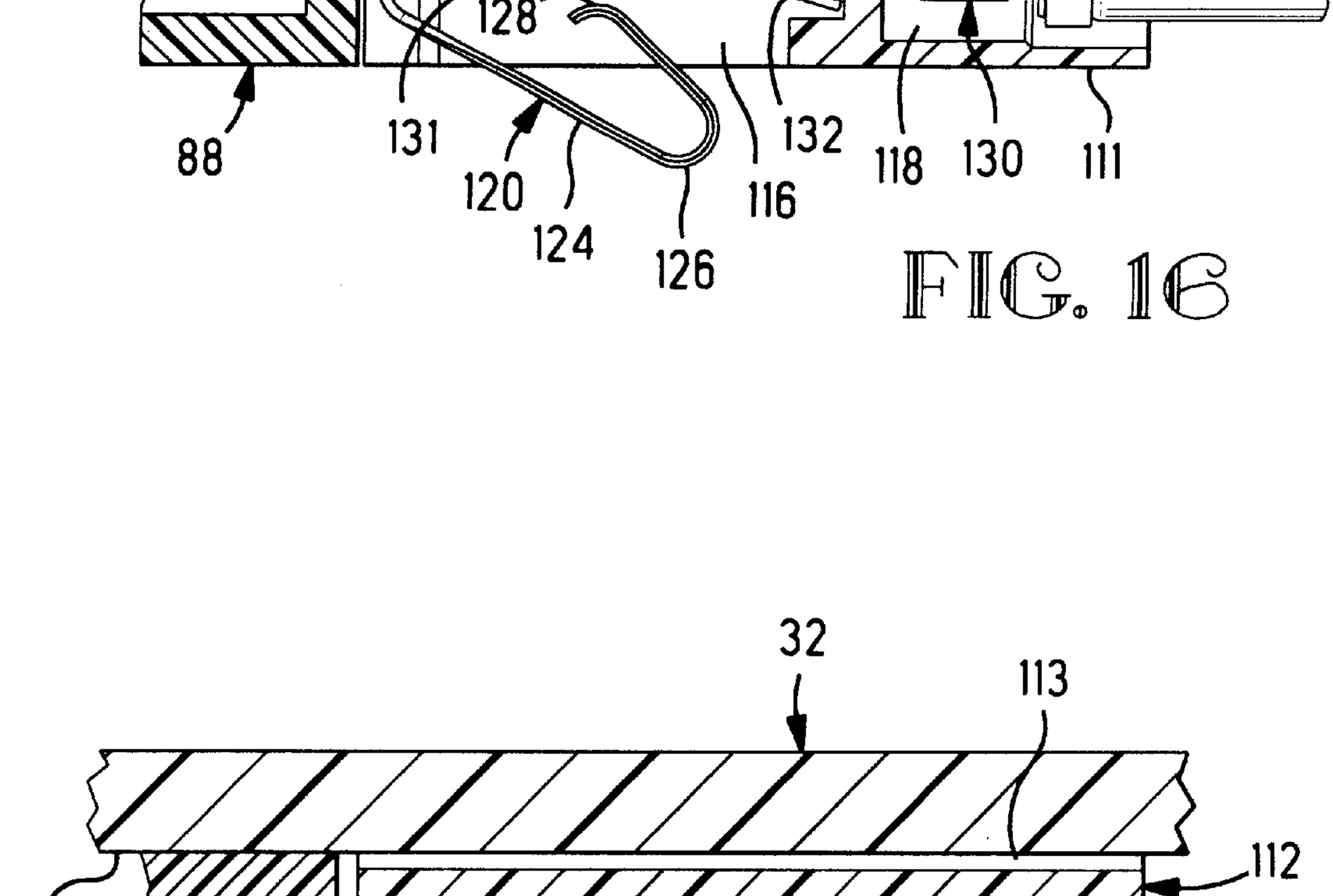
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FIG. 17

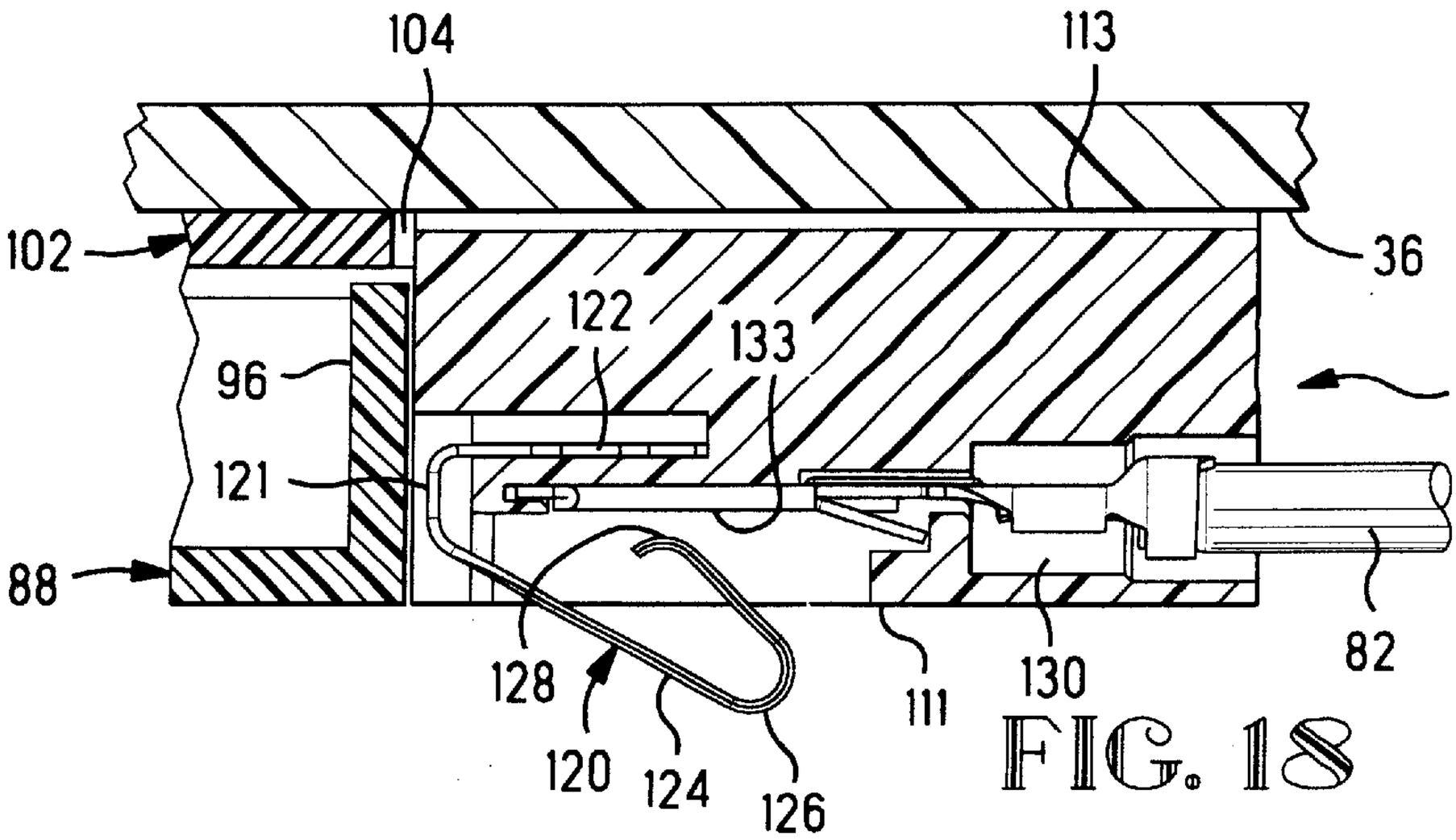
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FIG. 18

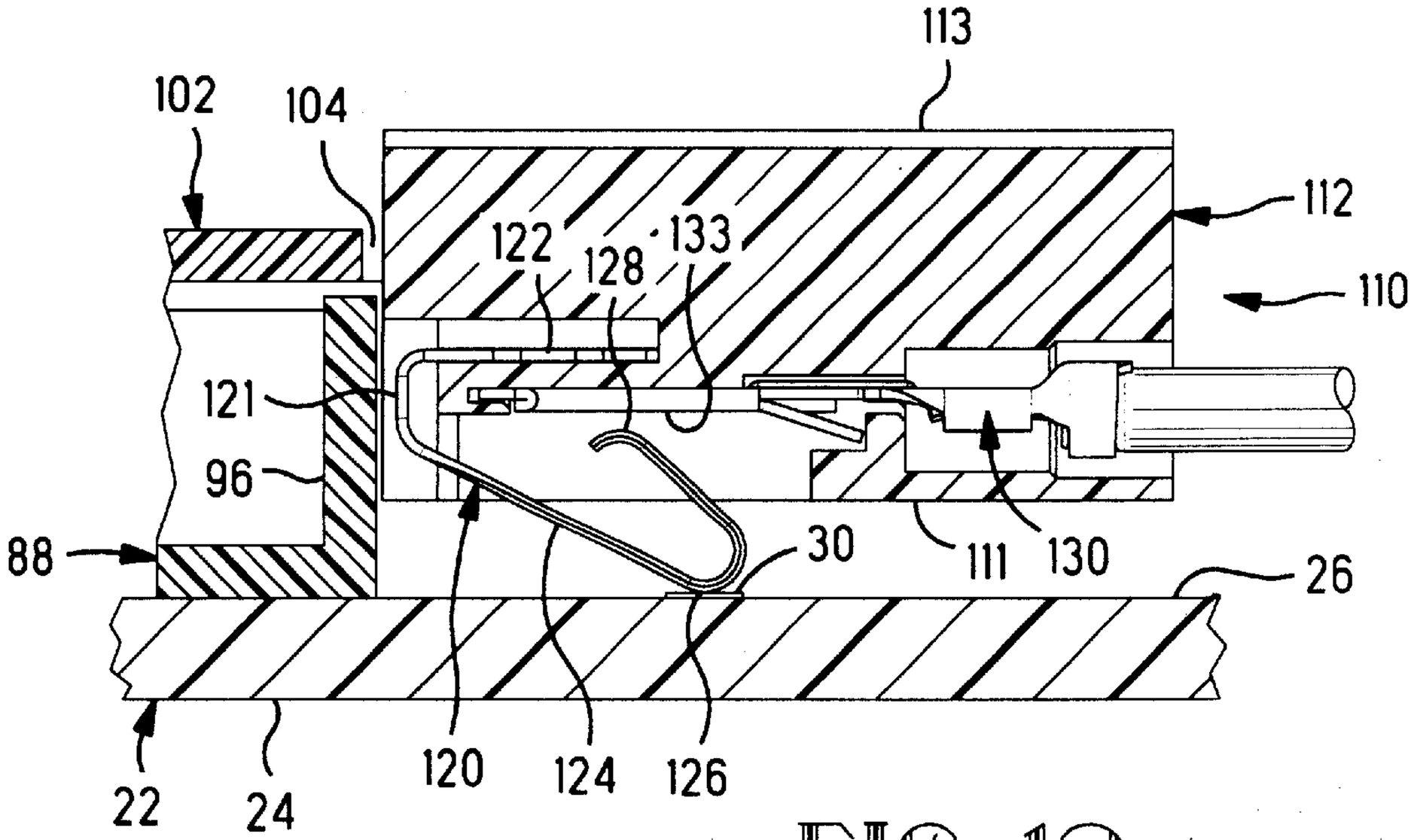
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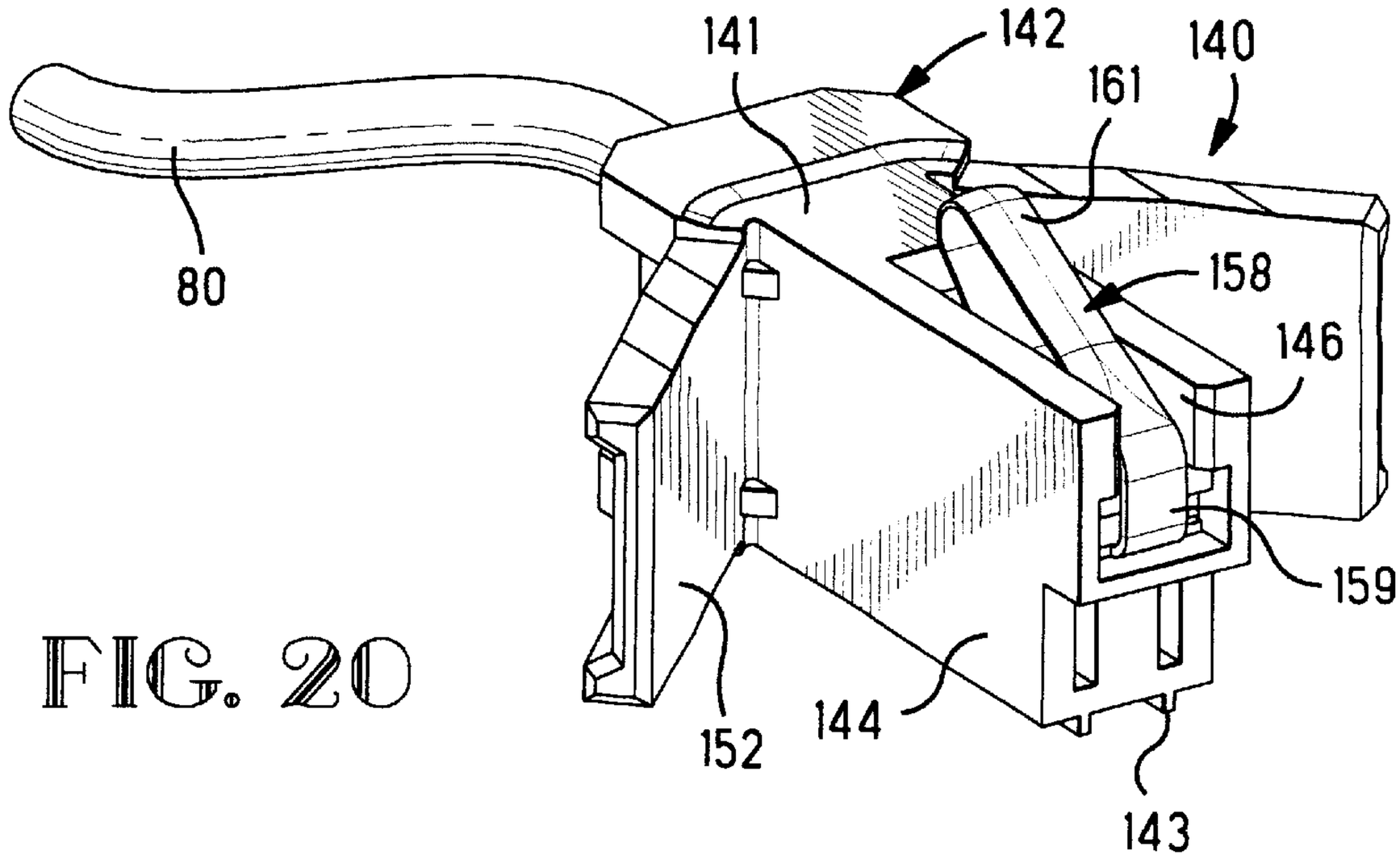
FIG. 19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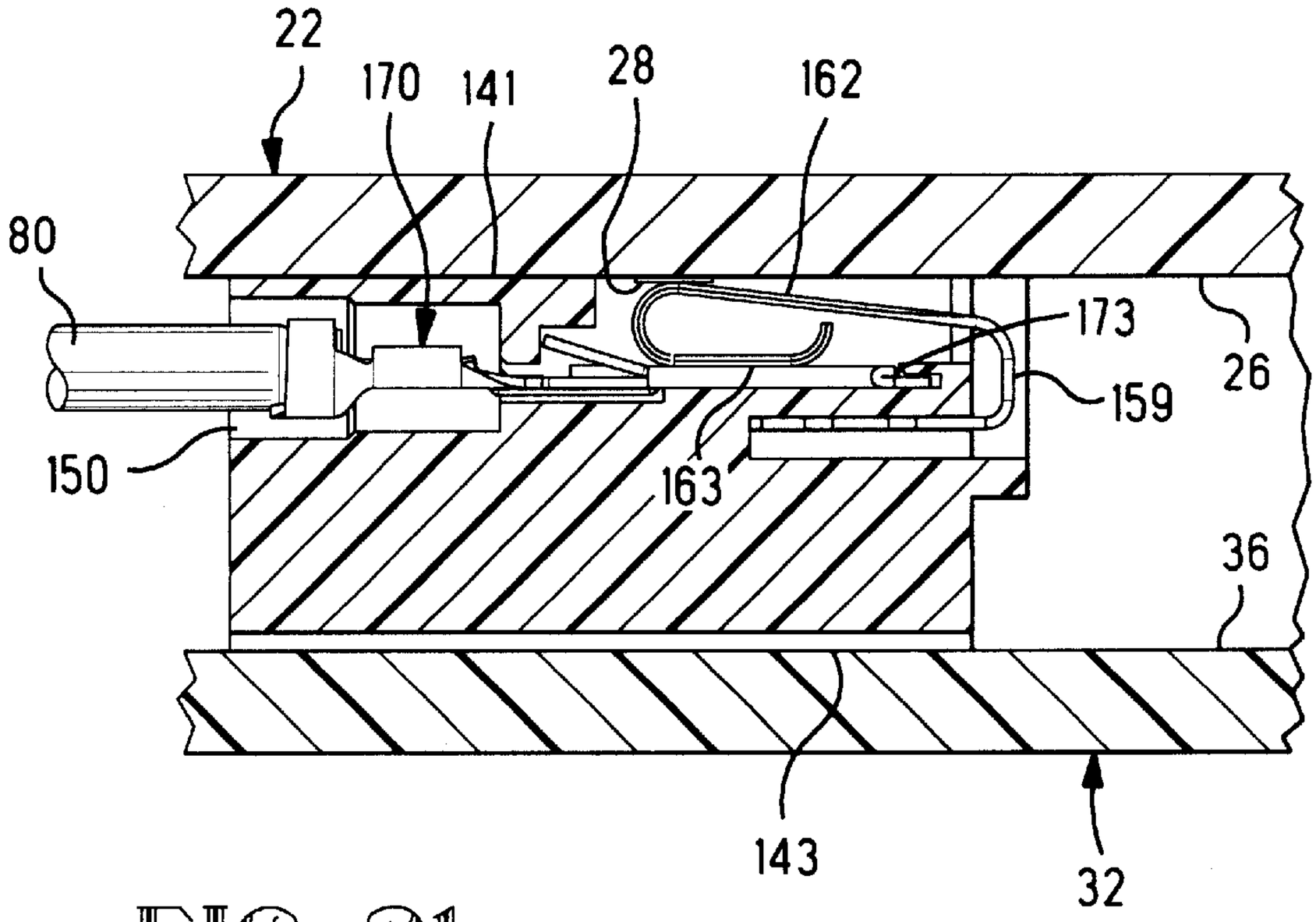
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FIG. 21

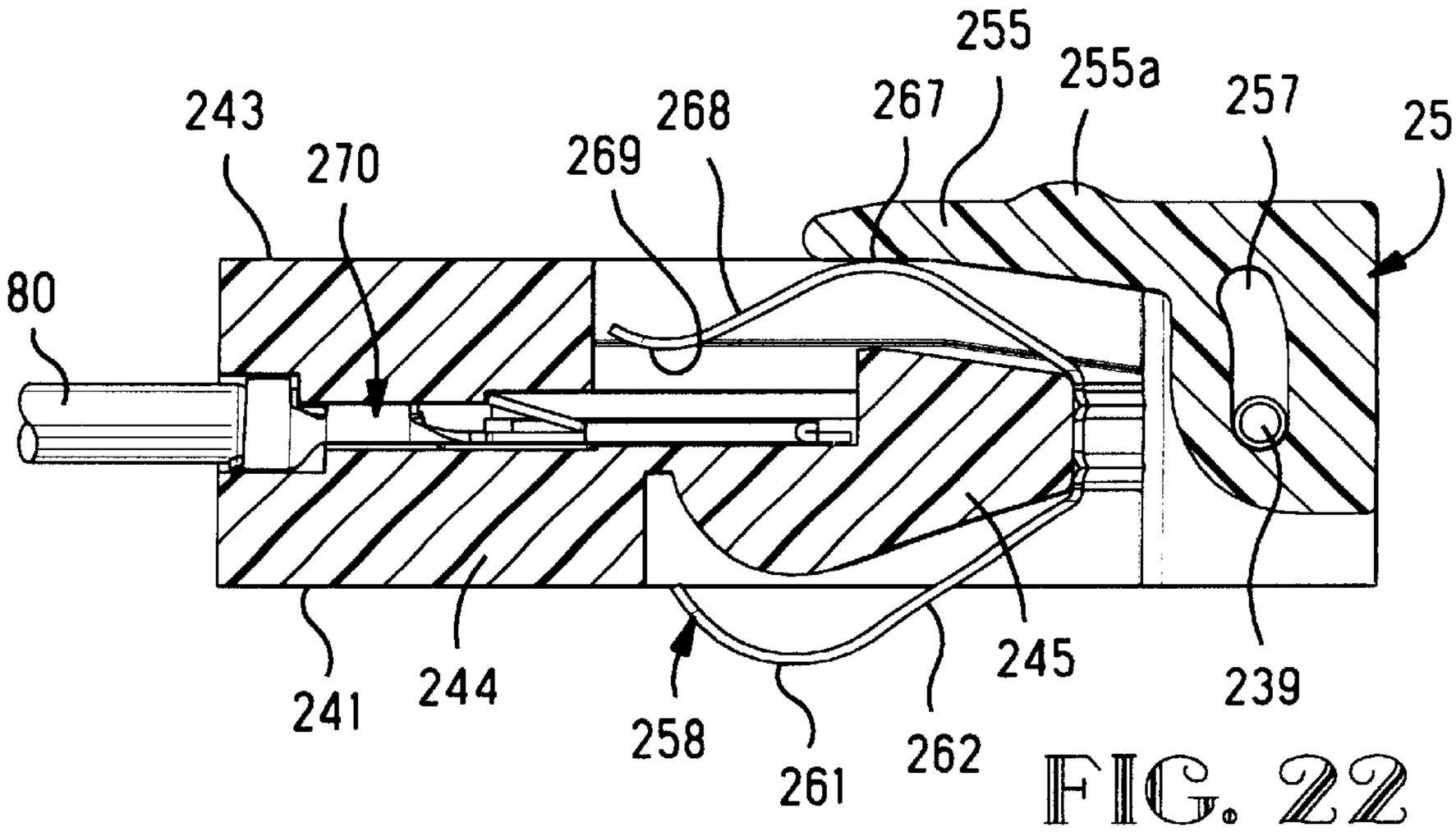
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FIG. 22

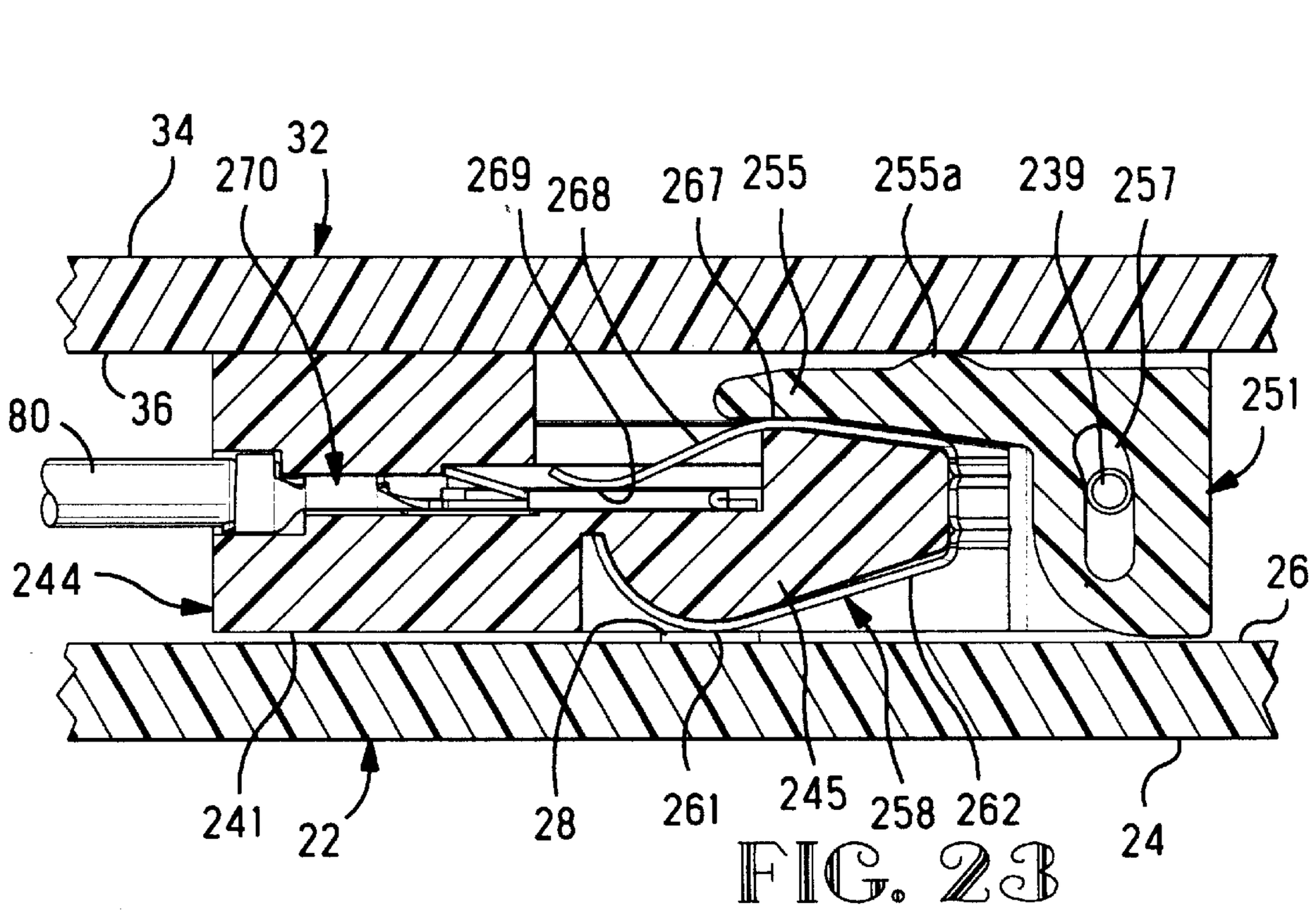
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FIG. 23

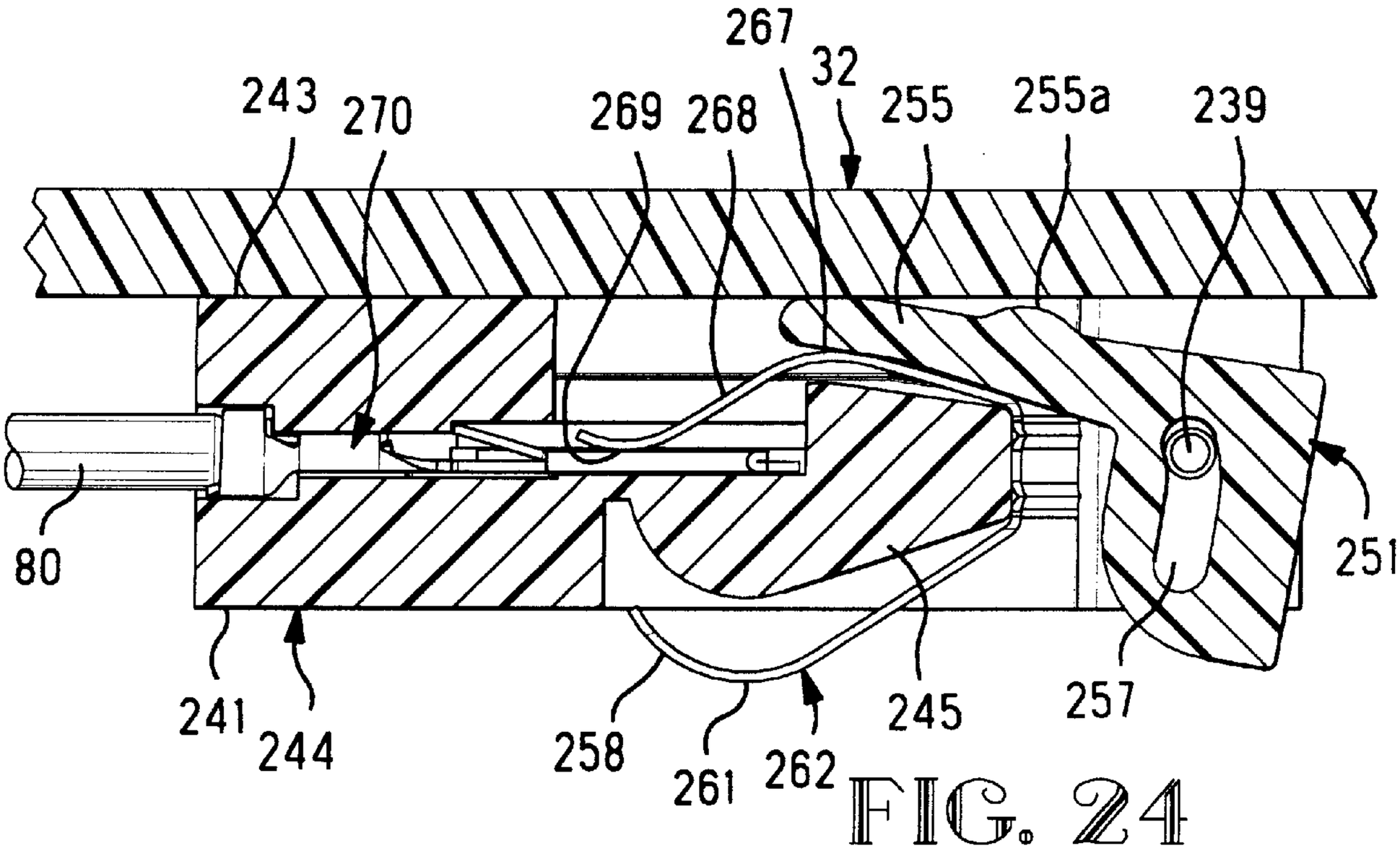
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FIG. 24

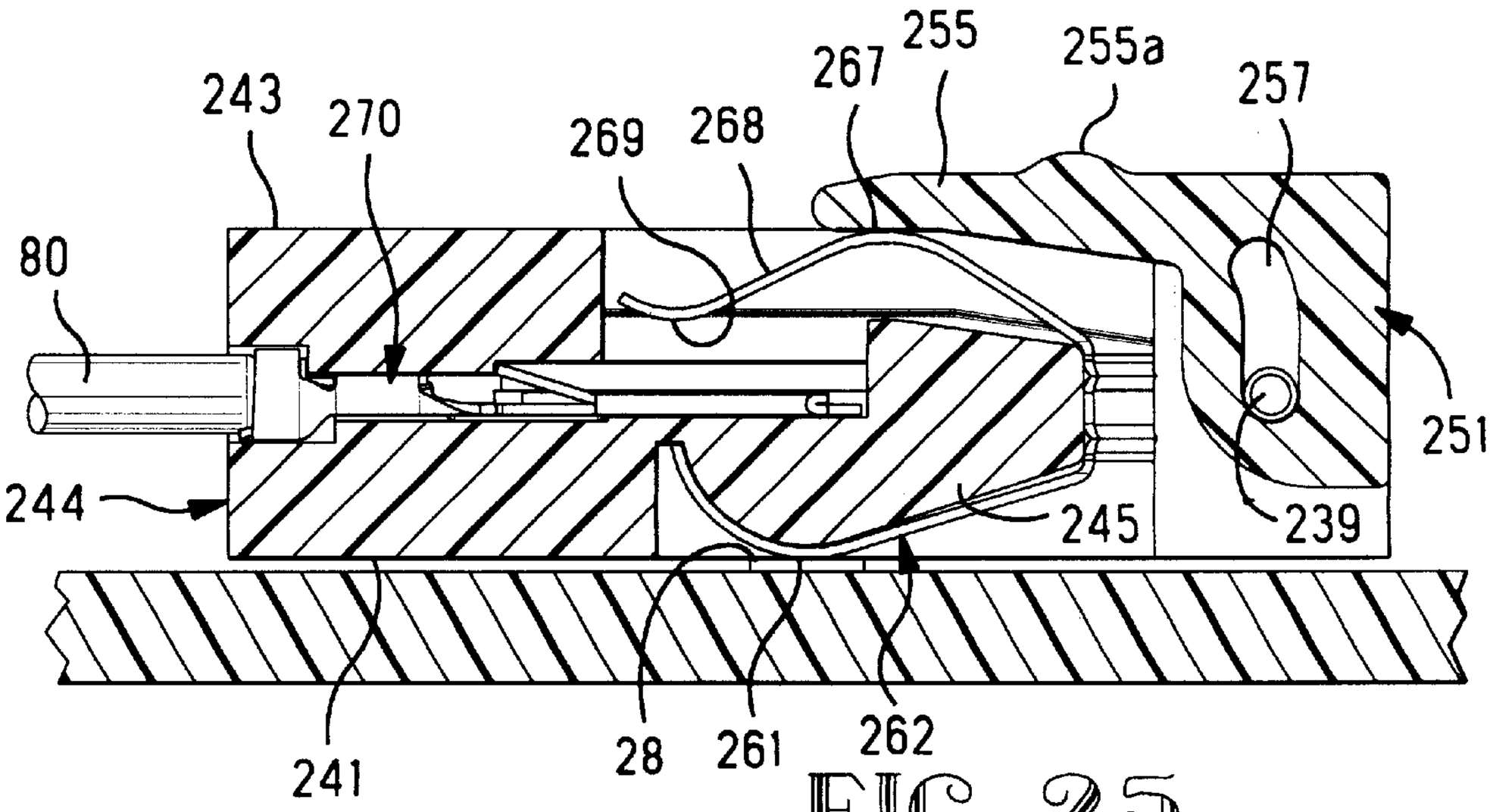
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FIG. 25

ELECTRICAL CONNECTOR AND PANEL ASSEMBLY

FIELD OF THE INVENTION

The present invention relates to the field of electrical connectors and more particularly to connectors used against two panels and the resulting assembly.

BACKGROUND OF THE INVENTION

For purposes of illustration, the invention will be discussed with reference to a glass panel door, such as used in a refrigerator or freezer in a grocery store or the like. It is to be understood that the term "freezer door" as used herein also includes refrigerator doors. It is to be further understood that the use of the connector is not limited to doors. For example, the invention is also suitable for use in windows for pools, or other areas subjected to wide temperature and moisture conditions.

Glass refrigerator and freezer doors typically are made from two pieces of glass separated by air or other insulating gas. A common problem associated with such glass doors is that moisture condenses on the outside glass owing to warm humid air striking the cold glass. This makes it difficult, if not impossible, for the customers to see what is in the refrigerator or freezer without holding the door open, which results in increased use of electricity for maintaining the desired temperature in the freezer or refrigerator. The prior art method now being used to minimize the condensation is to dispose a conductive element or film on the inside of the front glass, solder leads of a power cable to ends of the element or film and continually heat the outer glass, whether or not the ambient conditions are warm and humid. Additionally, should the glass be broken in the area of the electrical connections, the circuit to the glass remains active, possibly causing a safety hazard.

It is desirable, therefore, to have a system for warming the outer glass that senses when there is moisture on the glass and activated the heating element or film only for a sufficient time to dry the glass. Additionally it is desirable to have a system that will automatically deactivate the heating element if one or the other of the glass layers breaks in the area of the electrical connections to the element or film.

SUMMARY OF THE INVENTION

The present invention is directed to an electrical connector and a panel system that eliminate problems associated with the prior art. An electrical interlock connector for interconnecting a power source to an electrical unit within an apparatus includes an insulating housing containing at least one terminal-receiving cavity with an electrical terminal disposed therein and a first circuit member connected to the power source and attached to the housing. The electrical connector is mountable within the apparatus against portions thereof. The housing has first and second outer surfaces associated with respective portions of the apparatus and with the at least one terminal-receiving cavity in communication with the first outer surface. The terminal has a body portion and a spring section, the spring section having an outer connecting portion and an inner connecting portion with the outer connecting portion being adapted to be electrically connected to the electrical unit. The outer connecting portion resiliently extends outwardly of the first outer surface to an open position wherein the terminal and the first circuit member are electrically disconnected. The outer connecting portion is movable toward the first outer surface and into the

cavity to a closed position by a first portion of the apparatus upon mounting the connector in the apparatus against the first portion and a second portion. The connector has a section along the second outer surface that engages the second apparatus portion, the connector section being remote from and relatively movable with respect to the spring section. Whereby the inner connecting portion is at least in electrical connection with the first circuit member only when the connector is against the first portion and the second portion of the apparatus and the terminal is in its closed position thereby interconnecting the power source to the electrical unit. For purposes of discussing the invention, a panel assembly such as a freezer door is the "apparatus" and the electrical circuitry thereon is the "electrical unit".

In one embodiment, the connector section that engages the second apparatus portion is a second terminal that is disengaged from the circuit member unless biased by the second apparatus portion. The second terminal is disposed in a second terminal-receiving cavity. The second terminal has a body portion and a spring section, the spring section having an outer connecting section and an inner connecting section, the outer connecting section resiliently extending outwardly from the second outer surface of the housing to an open position. The outer connecting portion is movable toward the second outer surface and into the second cavity to a closed position by the second portion of the apparatus such that the inner portion of the second terminal electrically engages the first circuit member and concomitantly therewith the first apparatus portion moves the inner connecting portion of the terminal in the first cavity into electrical engagement with the body of the second terminal.

In another embodiment of the invention, the connector section is the second outer surface of the housing. The housing in this embodiment of the electrical interlock connector is freely slidable within a frame in a direction perpendicular to the first outer surface from a first position to a second position, when the outer connecting portion of the terminal is moved to the closed position, the inner connecting portion is brought into engagement with the first circuit member, so that only when both the housing is in the first position and the terminal is in the closed position is the terminal in electrical engagement with said the circuit member.

In a further embodiment of the invention, the connector section is the second outer surface of the housing that engages the second apparatus portion. Upon mounting the connector against the first and second apparatus portions, the spring section and the second housing surface are moved toward one another until the outer connecting portion is engaged with the electrical unit and the inner connecting portion electrically engages the circuit member.

In another embodiment of the invention, the connector section includes another spring section at an opposite end of the terminal body and an insulating actuation member mounted within the housing proximate the terminal. The second spring section has an outer connecting portion that resiliently extends outwardly of the second outer surface of the housing and an inner connecting portion that is adapted to electrically engage the circuit member upon moving the terminal to its closed position. The insulating member includes an elongate portion that extends along the outer connecting portion of the another spring such that the elongate portion is between the second apparatus portion and the outer connecting portion. Upon mounting the connector against respective the apparatus portions, the elongate member and the outer connecting portion are simultaneously moved toward the second outer surface with the inner

connecting section engaging the circuit member when the terminal reaches its closed position.

The invention is also directed to a panel Assembly including first and second panels, at least one of which includes an electrical circuit thereon having first and second conductive areas, each area being electrically connected to a power source by connectors made in accordance with the invention.

Embodiments of the invention will now be described by way of example with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an isometric pictorial representation of a panel assembly made in accordance with the present invention.

FIG. **2** is an exploded pictorial representation of the assembly of FIG. **1**.

FIG. **3** is an isometric view of a connector made in accordance with the invention as viewed from the inner end.

FIG. **4** is an isometric view of the connector of FIG. **3** as viewed from the outer end.

FIG. **5** is an exploded view of the connector of FIG. **3**.

FIG. **6** is a fragmentary cross-sectional view of the connector of FIG. **3** prior to assembling the panels thereto.

FIG. **7** is a view similar to that of FIG. **6** with the panels assembled on both sides of the connector.

FIG. **8** is a view similar to that of FIG. **6** with the front panel removed and illustrating the opening of the circuit.

FIG. **9** is a view similar to that of FIG. **6** with the back panel removed and illustrating the opening of the circuit.

FIG. **10** is an isometric view of a corner member with a spacer strip exploded therefrom.

FIG. **11** is a cross-sectional view of the corner member and a plurality of conductors disposed in a channel of the spacer strip.

FIG. **12** is an isometric view of an electronic module of the present invention.

FIG. **13** is an exploded view of an electronic module of FIG. **12** with the cover exploded therefrom and a connector therein.

FIG. **14** is a view similar to FIG. **13** with the connector exploded therefrom.

FIG. **15** is an isometric view of the connector of FIG. **13**.

FIG. **16** is a fragmentary cross-sectional view of the connector of FIG. **15** prior to assembling the panels thereto.

FIG. **17** is a view similar to that of FIG. **16** with the panels assembled on both sides of the connector.

FIG. **18** is a view similar to that of FIG. **16** with the front panel removed and illustrating the opening of the circuit.

FIG. **19** is a view similar to that of FIG. **16** with the back panel removed and illustrating the opening of the circuit.

FIG. **20** is an isometric view of an alternative embodiment of a connector suitable for use in the invention.

FIG. **21** is a cross-sectional view of the connector of FIG. **20** with the panels assembled on both sides of the connector.

FIG. **22** is a cross-sectional view of another connector embodiment of the present invention prior to assembling the panels thereto.

FIG. **23** is a view similar to that of FIG. **22** with the panels assembled on both sides of the connector.

FIG. **24** is a view similar to that of FIG. **23** with one of the panels removed.

FIG. **25** is a view similar to that of FIG. **23** with the other panel removed.

DETAILED DESCRIPTION OF AN EMBODIMENT OF THE INVENTION

Referring first to FIGS. **1** and **2**, assembly **20** includes a first or front panel **22** and a second or back panel **32** secured together and spaced a selected distance apart by a frame having spacer strips **38** that extend around and between the inner surfaces **26**, **36** of the panels **22**, **32**. For purposes of illustration, assembly **20** will be described in terms of a glass freezer door assembly with the outer surface **24** of first panel **22** being the side of the door that is exposed to ambient conditions and the outer surface **34** of second panel **32** being the side of the door that is exposed to the colder temperature. For purposes of clarity in understanding the invention, the spacer strips **38** are shown out of proportion with respect to the door panels **22**, **32**. Typically the spacers are on the order of ½ inch thick while the doors or other panels are considerably larger and are usually measured in feet.

In the embodiment shown, the inner surface **26** of the first or front panel **22** includes a resistive coating and two conductive areas or traces **28**, **30** proximate opposite edges thereof as shown in FIG. **2**. Upon connecting respective conductors **80**, **82** (shown in FIG. **13**) to the traces **28**, **30** the coating can be energized to warm the front panel **22** to prevent an accumulation of moisture on the exposed outer surface **24** thereof. It is to be recognized that the invention is not limited to the use of a resistive coating and that other circuitry may be used to provide the same function. Additionally, it is to be recognized that for ease of manufacturing and limiting inventory, it may be desirable to use the same coated panel for both the front and back of the assembly. When the panel assembly is a freezer door or the like, it is to be recognized that the rear panel would not be warmed.

Spacer strips **38** define a conductor receiving channel **39** for receiving conductors **84**, as best seen in FIGS. **10** and **11**. In the embodiment shown in FIGS. **1** and **2**, the spacer strips **38** are joined together at the upper left hand corner of assembly **20** by electrical connector **40** and at the other three corners by corner members **74**. For purposes of clarity, two of the corners **74** and a spacer **8** have been omitted from the drawing. FIG. **2** also shows an electronic module **86** in phantom that may be used in the assembly of the invention as more fully explained below. In the arrangement shown, the door is designed to include hinges on its left hand side. It is to be understood that connector **40** can be used in a right hand corner and the door include hinges on its right hand side.

Referring now to FIGS. **3** through **7**, connector **40** includes insulating housing **42**, a first or front panel engaging terminal **58**, and a second or back panel terminal **64** secured therein. Housing **42** includes a terminal-receiver body **44** having first and second outer surfaces **41**, **43**, a first terminal-receiving cavity **46**, a second terminal-receiving cavity **48** separated by inner wall **45**, and a circuit member-receiving passageway **50** adapted to receive first circuit member **70** terminated to conductor **80**, which in turn is connected to the power source (not show). Passageway **50** extends into and along the lower surface of second terminal-receiving cavity **48**. Housing **42** further includes retention portions **52** extending outwardly therefrom and having edges **56** thereof dimensioned to be received in an interference fit in portions of respective channels **39** of spacer strips **38** when the door is assembled, as shown in FIG. **10**.

Retention portions **52** include a recess along the outer sides thereof for receiving conductors **84** therein upon assembly of the door. As can be seen from these Figures, the retention portions extend at an angle to the terminal-receiving body **44** and at a right angle with respect to each other. Connector **40** is designed so that it may be used in either a right or a left handed door or panel assembly. Additionally, housing **42** is designed so that it may be molded in a single action mold thereby permitting cost effective manufacturing.

First and second terminals **58** and **64** are similar in structure. First terminal **58** includes flat body portion **60** and a spring section defined by a U-shaped spring arm **62** joined to body portion **58** by bight **59**. Spring arm **62** includes an outer connecting portion **61** proximate the base of the "U" engaging the trace **28** on a first apparatus portion or front panel surface **26**, and an inner connecting portion **63** at the leading end of the arm **62** for engaging second terminal **64**. Second terminal **64** includes body portion **66** and a spring section defined by a U-shaped spring arm **68** joined to body portion **66** by bight **65**. Spring arm **68** includes An outer connecting portion **67** proximate the base of the "U" for engaging a second apparatus portion or the inner surface **36** of back panel **32**, and inner connecting portion **69** at the leading end of the arm **68** for engaging first circuit member **70**, when the door is assembled as can be seen in FIG. **7**. If connector **40** is being used in a door assembly that uses identical front and back panels, it will be necessary to provide some insulation between second outer connecting portion **69** and inner surface **36** of panel **32**. The insulation is not necessary for a back panel that does not have a conductive coating.

First and second terminals **58**, **64** are assembled in terminal-receiving body **44** by first inserting bight **59** of first terminal **58** into first terminal-receiving cavity **46** such that body portion **60** is secured in slot **47** and spring arm **62** is in cavity **46**, ax best seen in FIGS. **5**, **6**, and **7**. The body portion **66** of back or second terminal **64** is then inserted into slot **49** of the first terminal-receiving cavity **46** and the spring arm **68** is concomitantly moved into the second terminal-receiving cavity **48** with bight **65** extending around the outer edge of inner wall **45** between the two cavities **46**, **48**. As best seen in FIGS. **3**, **4** and **6**, the spring arms **62**, **68** and first and second outer connecting portions **61**, **67** resiliently extend outwardly from the respective first and second surfaces and the corresponding cavities **46**, **48** to an open position. Circuit member **70** includes a tab portion **73** having a leading end **71** that is trapped in slot **51** within cavity **48** and a retention lance **72** that engages surface **53** along the base of cavity **48**.

Prior to attaching the panels **22**, **32** along outer surfaces **41**, **43** of the connector **40**, first circuit member **70** is inserted into and secured in circuit member-receiving passageway **50** with tab section **73** extending into second cavity **48**, as described above. Upon assembling the door with the panels in a first posit-on, the first apparatus portion or surface **26** of front panel **22** engages and compress the spring arm **62** of first terminal **58** moving arm **62** toward surface **41** and into cavity **46**, thereby bringing the outer connecting portion **61** into engagement with trace **28** on front panel surface **26** and the inner connecting portion **63** into engagement with body **66** of second terminal **64**. Concomitantly therewith the second apparatus portion or surface **36** of back panel **32** compresses the spring arm **68** of the second terminal **64** moving arm **68** toward second surface **43** and into cavity **48**, thereby bringing outer connecting portion **69** thereof into engagement with tab portion **73** of first circuit member **70**, which is connected to the power source (not shown) by conductor **80** shown in FIG. **7**. When power is supplied to the assembly, current travels through first circuit member **70**, second terminal **64** to first terminal **58** and to trace **28** of front panel **22**, through the resistive coating of the panel and through another conductor **82** terminated to trace **30** on surface **26**, as best seen in FIGS. **13** and **14**.

In the event one of the panels **22**, **32** moves to a second position, that is the panel is removed or the glass is broken, while the system is energized, the circuit path is automatically broken by the connector. For purposes of this disclosure the term "removed" as applied to one of the panels is to be understood to include breaking of the panel. Typically, glass used for freezer doors is the kind that shatters when it breaks, thus it is "removed" from the assembly.

The automatic breaking of the circuit is best understood by referring to FIGS. **8** and **9**. If the front panel **22** is removed, the compressive force against spring arm **62** is no longer present thus allowing spring arm **62** to resile outwardly thereby breaking electrical connection between inner connecting portion **61** and second terminal body **66** and returning to the position shown in FIG. **8**. If, on the other hand, the rear panel **32** is removed, compressive force against spring arm **68** of second terminal **64** is released and arm **68** resiles outwardly thus breaking the connection between inner connecting portion **69** and first circuit member **70**, as shown in FIG. **9**.

FIGS. **10** and **11** show the structure of corner member **74** having an angled center portion **75** and retention portions **76** extending outwardly from center portion **75**. The retention portions **76** are at a right angle with respect to each other. The center portion **75** and retention portions **76** define a conductor-receiving recess **78** extending along the outer surface of the corner member for receiving conductors **84** therealong. The base of the recess **78** includes a slot **79** provide some resiliency to portion **76** for ease of insertion into conductor-receiving channel **39** of spacer strip **38**. Edges **77** of retention portions **76** are configured to provide an interference fit in portion **37** of the conductor-receiving channel **39** of spacer strip **38**, as best seen in FIG. **11**. The retention portions **76** are configured in the same manner as those of connector **40**, thus making any corner member **74** interchangeable with connector **40**. FIG. **11** further illustrates three conductors **84** disposed in channel **39**. It is to be understood that the number of conductors **84** will vary depending upon the desired electrical needs of the assembly. If a panel is removed or broken, it also is desirable, for purposes of safety, that the same or a similar type of interlock connector or other circuitry be provided that would automatically assure power is turned off at the connection to second trace **30**.

In addition to providing the capability of warming the outer panel of a freezer door or the like to minimize condensation of moisture thereon, it further is desirable that the assembly **20** have the capability to sense when moisture is beginning to condense and to activate the warming circuitry only when needed. The ability of the assembly **20** to turn the electrical unit on and off results in a saving of electrical energy and is more cost efficient than the prior art door assemblies.

FIGS. **2**, and **12** through **19** show a module **86** that may be used to house electronic circuitry for sensing moisture or other information and turning the power off and on as needed. In the embodiment shown module **86** is disposed proximate the bottom trace **30** on surface **26** of panel **22**. Module **86** includes a two part housing **87** having a base **88** and cover **102**, a second connector **110** adapted to engage the

second trace **30** on panel surface **26** and a circuit board **106** having electronic components **108** thereon. Base **88** includes walls **90** having conductor or wire entrances **92**, **93** therein for receiving conductors **84** therethrough for connection to circuit board **106** and retention portions **91** extending outwardly therefrom for attachment to ends of corresponding spacer strips **38**, as shown in phantom in FIG. **2**. Base **88** further includes connector frame **96** dimensioned to receive connector **110** therein.

Connector **110** includes an insulating housing **112** having first and second outer surfaces, **111**, **113**. Support shoulders **114** extend outwardly from side walls **115** of the housing **112**. Housing **112** is dimensioned to be received within frame **96** with shoulders **114** extending through recesses **95** in side walls of frame **96**. Housing **112** is freely slidable in a direction perpendicular to the first surface **111** from a first position to a second position Housing **112** further includes terminal-receiving cavity **116** and slot **117** for receiving panel engaging terminal **120** therein and circuit member-receiving passageway **118** for receiving circuit member **130** therein, as best seen in FIGS. **16** through **19**.

Terminal **120** has essentially the same shape as first and second terminals **58**, **64** described above. Terminal **120** includes body portion **122** and a spring section defined by a U-shaped spring arm **124** joined to body portion **122** by bight **121**. Spring arm **124** includes an outer connecting portion **126** proximate the base of the "U" for engaging the trace **30** on front panel surface **26** and an inner connecting portion **129** at the leading end of the arm **124** for engaging circuit member **130**, as shown in FIG. **17**. Upon inserting terminal **124** into terminal-receiving cavity **116**, spring arm **124** and outer connecting portion **126** thereon resiliently extends outwardly from the first housing surface **111**, as seen in FIG. **19**. Circuit member **130** connected to a power source via conductor **82** is inserted into circuit member-receiving passageway **118** and secured therein at forward end **131** and by retention tab **132** in the same manner as circuit member **70** in first connector **40**.

Module **86** is assembled by connecting conductors **34** and the other end of conductor **82** to circuit board **106** and placing connector **110** into connector frame **96** in the first position, as shown in FIG. **13**. Cover **102** is then secured to base **88**. Upon inserting retention tabs **91** into respective ends of spacer strips **38** (not shown) and securing panels **22**, **32** together, spring arm **124** is compressed by first apparatus portion such that the outer connecting portion **126** of terminal spring arm **124** engages trace **30** of the electrical unit and the inner connecting portion **128** engages tab **133** of circuit member **130**, thereby interconnecting the power source to the electrical unit. FIGS. **16** and **17** illustrate the position of connector **110** in frame **96** before and after panels **22**, **32** have been secured together. The second apparatus portion or back panel **32** prevents housing **112** from moving from the first position to the second position in frame **96** owing to the compressive force exerted on spring arm **124** by first apparatus portion or front panel **22** that moved arm **124** into terminal-receiving cavity **116**. FIGS. **18** and **19** illustrate the position of connector **110** when the front panel **22** is removed and when back panel **32** is removed, respectively. Upon decreasing the compressive force on spring arm **124** by removal or breakage of front panel **22**, spring arm **124** resiles outwardly from first outer surface Ill to an open position, breaking the electrical Connection between inner connecting portion **128** and circuit member **130**, as shown in FIG. **18**. Upon removal or breakage of back panel **32**, the compressive force between second outer surface **113** of housing **112** and panel **32** is removed. Housing **112** including terminal **120** and circuit member **130** then moves to the second position with second housing surface **113** extending outwardly of frame **96** and through opening **104** in cover **102** owing to the force of spring arm **124** as it resiles to its open state, as shown in FIG. **19**. Concomitantly therewith the inner connecting portion **128** is disengaged from circuit member **130**. The sliding movement or float of the housing **112** is stopped when shoulders **114** engage the inner surface of cover **102** (not shown).

As shown in FIGS. **12** and **13**, base **88** further includes an opening **89** therethrough for a sensor device **108** or other electronic unit, circuit board supports **98** and a plurality of posts or projections **94** used as conductor guides and to provide strain relief for the conductors **84** being brought into module **86**. Module **86** is more fully described in U.S. patent application Ser. No. 09/245,753 filed concomitantly herewith and herein incorporated by reference.

On the other hand, if the warming system is always to remain "on", another interlock connector such as connector **40** may be provided at the lower portion of the door that electrically engages trace **30** instead of the module described above . Alternatively, if the conductive areas or circuit pads of a continuous trace are proximate one another, a single connector housing having two sets of terminals may be used.

FIGS. **20** and **21** illustrate an alternative embodiment **140** of a connector made in accordance with the invention. In this embodiment, connector **140** includes an insulating housing **142** having first and second outer surfaces **141**, **143** and a first or front panel engaging terminal **158** secured therein. Housing **142** includes a terminal-receiving body **144** and a pair of retention portions **152** like those previously described. Body **144** includes a terminal-receiving cavity **146** and a circuit member-receiving passageway **150**. Front panel engaging terminal **158** includes flat body portion **160** and a U-shaped spring arm **162** joined to body portion **160** by bight **159**. Spring arm **162** includes a first or outer connecting portion **161** proximate the base of the "U" for engaging the trace **28** of an electrical unit such as front panel surface **26** and a second or inner connecting portion **163** at the leading end of the arm **162** for engaging circuit member **170**. In this embodiment the circuit will be broken if the front panel is removed or broken. FIGS. **22** through **25** illustrate a further embodiment **240** of the invention that uses a connector having a single terminal **258** and an insulating member **251** positioned between the front and back panels **22**, **32**, respectively. The power circuit is broken when either the front or back panel **22**, **32** is removed or broken. FIG. **22** illustrates a cross-sectional view of the connector **240** after circuit member **270** has been inserted into the housing **242**. Housing **242** having first and second outer surfaces **241**, **243** includes a terminal-receiving cavity having portions **246**, **248** on both sides of a center wall **245**. An L-shaped insulating member **251** is mounted on mounting post **239** proximate the wall **245** at the open end of the passageway portions **246**, **248** in a manner to permit movement from an initial position to at least a second position in the embodiment shown, the base **253** of insulating member **251** includes a slot **257** that is dimensioned to slide along mounting post **239** as member **251** is moved. The movement may be translational as illustrated in FIG. **25** or a combination of translational and pivotal as illustrated in FIG. **24**. It is to be recognized that other arrangements may be used to mount an insulating member in the connector housing. When the inner surface **36** of back panel **32** includes circuitry thereon in addition to that on the front panel **22** the insulating member **251** eliminates the need to provide an insulating tape or layer on a conductive surface of the back panel.

Terminal **258** is essentially "U"-shaped with each of the first and second arms **262**, **268** thereof having rounded sides and defining outer connecting portions **261**, **267** thereon. The leading end of the first arm is disposed in the housing passageway **246** with the curved panel-engaging outer connecting portion **261** extending outwardly from housing passageway **246**. The leading end of the second arm **268** includes inner connecting portion **269** and is adapted to electrically engage the circuit member **270** when the panels **22**, **32** are assembled on both sides of the connector **240**. It is to be understood that the leading end of second arm **268** may have a reverse curve, as shown, or other configurations as known in the art. The leg **255** of insulating L-shaped member **251** extends into cavity **248** beyond the outer connecting portion **267** of arm **268**. When arm **262** engages conductive trace **28** of panel **22**, a raised area **255***a* on insulating leg **255** engages the inside surface of rear panel **32** thus preventing outer connecting portion **267** of terminal **258** from electrically engaging the inside surface **36** of rear panel **32** in the panel assembly, as seen in FIG. **23**. In this embodiment, both of the arms **262**, **268** of terminal **238** are compressed inwardly with respect to surfaces **241** and **243** when panels **22**, **32** are secured thereto. When the door is assembled, the mounting post **239** is proximate the center of slot **257**.

FIGS. **24** and **25** illustrate how terminal **258** automatically breaks the circuit to circuit member **270** if either of the panels **22**, **32** is removed or broken. If the front panel **22** is removed or broken, the front arm **262** springs outwardly, causing insulating member **251** to move in the plane in a direction away from the back panel **32** until the mounting post **239** engages the rearmost end of slot **257**. The insulating leg **255** also pivots and slides rearwardly along the connecting portion **267** of rear arm **268** of terminal **258**, reducing pressure on the arm **268** and allowing the connecting portion **269** to become disengaged from circuit member **270**. If the back panel **32** is removed or broken, the release of the compressive force on the spring arm **268** of terminal **258** causes the connecting portion **269** to break the circuit as the spring arm **268** resiles outwardly beyond second outer surface **243**. Concomitantly the insulating member **251** moves in the plane in a direction toward the front panel **22** until the mounting post **239** is proximate the forward most end of slot **257**, as shown in FIG. **25**. Embodiment **240** has the advantage of being usable when the back panel **32** includes a conductive coating or other circuitry that should not come into electrical engagement with terminal **258**. The insulating member **251** eliminates the need to apply an insulating layer along the interior surface **36** of the back panel **32** to prevent electrical contact between a terminal and the back panel, as previously described.

The present invention provides interlock connectors that include safety features for a an apparatus, such as a panel assembly that automatically break the circuit to a power source if either panel is moved from a first or assembled position to a second or partially assembled position. The connectors of the present invention are suitable for use as an interlock between power sources and electrical units in various kinds of apparatus. It is also to be recognized that the apparatus portions against which the connector is mounted is not limited to opposed portions. For example, an electrical terminal in the connector may be formed in such a manner that the apparatus engaging portions are on adjacent sides of the housing.

It is thought that the electrical connector and panel assembly therefor of the present invention and many of their attendant advantages will be understood from the foregoing description. It is apparent that various changes may be made in the form, construction, and arrangement of parts thereof without departing from the spirit or scope of the invention, or sacrificing all of its material advantages.

We claim:

1. An electrical interlock connector for interconnecting a power source to an electrical unit within an apparatus, said electrical connector being mountable within the apparatus against portions thereof and comprising:

an insulating housing with first and second outer surfaces associated with respective portions of the apparatus;

the housing containing at least one terminal-receiving cavity in communication with said first outer surface;

an electrical terminal disposed in said at least one cavity and having a body portion and a spring section, said spring section having an outer connecting portion and an inner connecting portion with said outer connecting portion being adapted to be electrically connected to said electrical unit; and

a first circuit member connected to said power source and attached to said housing;

said outer connecting portion resiliently extends outwardly of said first outer surface to an open position wherein said terminal and said first circuit member are electrically disconnected;

said outer connecting portion being movable toward said first outer surface and into said cavity to a closed position by a first portion of the apparatus upon mounting the connector in the apparatus against said first portion and a second portion, said connector having a section along said second outer surface that engages a second apparatus portion, said connector section being remote from and relatively movable with respect to said spring section;

whereby said inner connecting portion is at least in electrical connection with said first circuit member only when said connector is against said first portion and said second portion of the apparatus and said terminal is in its closed position thereby interconnecting said power source to said electrical unit.

2. The electrical interlock connector of claim **1** wherein the connector section is a second terminal that is disengaged from said first circuit member unless biased by said second apparatus portion, said second terminal being disposed in a second terminal-receiving cavity in said housing, said second terminal having a body portion and a spring section including an outer connecting section and an inner connecting section such that upon biasing said second terminal said inner connecting section thereof engages the first circuit member and concomitantly therewith said first apparatus portion moves the inner connecting portion of the terminal in said at least one cavity into electrical engagement with the body of the second terminal thereby effecting interconnection between said power source and said electrical unit.

3. The electrical interlock connector of claim **1** wherein said connector section is an insulating member that is biased by said second apparatus portion such that a second spring section of the terminal engages said circuit member, said insulating member being mounted within said housing proximate said terminal in a manner to permit movement from an initial position to at least one other position, the second spring section having an outer connecting portion resiliently extending outwardly of the second outer surface of the housing and an inner connecting portion that is adapted to electrically engage the circuit member upon being moved by the insulating member to its closed position.

4. The electrical interlock connector of claim 1 wherein said connector portion is the second outer surface of said housing, said second surface being in engagement with said second apparatus portion when the connector is mounted in the apparatus.

5. The electrical interlock connector of claim 4 wherein said connector is disposed in and is freely slidable within a frame in a direction perpendicular to the first outer surface from a first position to a second position, such that the outer connecting portion of the terminal is moved to the closed position and the inner connecting portion thereof is brought into engagement with the first circuit member.

6. An electrical interlock connector for interconnecting a power source to an electrical unit within an apparatus, said electrical connector being mountable within the apparatus against portions thereof, and comprising:

an insulating housing with first and second outer surfaces and having first and second terminal-receiving cavities;

first and second terminals associated with respective ones of said first and second terminal-receiving cavities, said first and second terminals including body portions and spring sections, said spring sections being disposed in respective ones of said terminal-receiving cavities and having outer connecting portions and inner connecting portions, with said outer connecting portions resiliently extend outwardly of said first and second surfaces, respectively, to open positions wherein said first and second terminals are electrically isolated when resiled; and

a first circuit member connected to said power source and attached to said housing and at least exposed within said second terminal-receiving cavity to be engaged by said second terminal when in its closed position;

said first terminal being adapted to be electrically connected to said electrical unit and said second terminal being adapted to be connected to said first circuit member;

said outer connecting portion of said first terminal being movable toward said first surface to a closed position within said first cavity by engagement with a first portion of the apparatus when the connector is mounted therein wherein said first inner connecting portion is in electrical engagement with said body portion of said second terminal within said first cavity; and

said outer connecting portion of said second terminal being movable toward said second surface to a closed position within said second cavity by engagement with a second portion of the apparatus wherein said inner connecting portion of said second terminal is in electrical engagement with said first circuit member upon mounting of the connector within the apparatus;

so that only when both said first and second terminals are in their closed positions is said first terminal in electrical engagement with said first circuit member thereby interconnecting said power source to said electrical unit.

7. The electrical interlock connector of claim 6 wherein said first and second terminal-receiving cavities extend to a common end wall of said housing, said first and second cavities being separated by an inner housing wall.

8. The electrical interlock connector of claim 6 wherein said first and second spring sections are U-shaped spring arms, and are joined to respective said body portions by bights.

9. The electrical interlock connector of claim 8 wherein each outer connecting portions is proximate a base of the "U" of a respective one of said first and second terminals and each of said inner connecting portions is proximate a leading end of said spring arm of a respective one of said first and second terminals.

10. The electrical interlock connector of claim 8 wherein said first and second terminal-receiving cavities extend to a common end wall of said housing and are separated by an inner wall thereof, said first terminal-receiving cavity including first and second terminal-receiving slots, said body portion of said first terminal being inserted into said first slot with said bight of said first terminal being at an inner end of said cavity and said spring arm of said first terminal extending toward an open end of said first cavity, and said second terminal being inserted into said housing with said body portion of said second terminal being received in said second slot and extending between said first terminal body portion and said spring arm thereof, said bight of said second terminal being disposed around said inner wall with said spring arm of said second terminal extending toward an inner end of said second cavity.

11. The electrical interlock connector of claim 9 wherein said first circuit member includes a conductive tab portion extending into said second terminal-receiving cavity, such that upon moving said spring section of said second terminal to said closed position, said inner connecting portion of said second terminal electrically engages said tab portion of said circuit member.

12. The electrical interlock connector of claim 6 wherein said first circuit member includes a third terminal terminated to a conductor, said third terminal including a connecting section exposed within said second terminal-receiving cavity and adapted to be electrically connected to said inner connecting portion of said second terminal upon moving said first and second terminals to said closed positions.

13. The electrical interlock connector of claim 12 wherein said third terminal is secured in a circuit member-receiving passageway that extends into said housing and is in communication with said second terminal-receiving cavity, and said connecting section of said first circuit member is a tab that extends into said second terminal-receiving cavity.

14. The electrical interlock connector of claim 6 wherein said housing further includes retention portions extending outwardly from opposite sides of a terminal-receiving body containing said first and second terminal-receiving cavities, said retention portions being adapted to retain said connector in a desired position for connection to said electrical unit.

15. The electrical interlock connector of claim 14 wherein said retention portions extend at an angle to said terminal-receiving body and at a right angle with respect to one another such that said connector may be secured in a corner of an assembly for electrical connection to said electrical unit.

16. The electrical interlock connector of claim 15 wherein said apparatus is a panel assembly and wherein said first and second apparatus portions are opposed to one another, each having respective portions against which said connector is mounted.

17. The electrical interlock connector of claim 16 wherein said first and second panels of said panel assembly are glass.

18. The electrical interlock connector of claim 14 wherein said retention portions further include respective recesses along the outer surfaces thereof adapted to receive electrical conductors therealong.

19. An electrical interlock connector for interconnecting a power source to an electrical unit within an apparatus, said electrical connector being mountable within the apparatus against portions thereof and comprising:

an insulating housing with first and second surfaces, said housing being freely slidable within a frame in a direction perpendicular to said first surface from a first position to a second position;

an electrical terminal disposed in a cavity in said housing, said terminal having an outer connecting portion and an inner connecting portion, said outer connecting portion being adapted to be electrically connected to said electrical unit; and

a first circuit member connected to said power source and attached to said housing and at least exposed within said cavity;

wherein said outer connecting portion resiliently extends outwardly of said first surface to an open position wherein said terminal and said first circuit member are electrically spaced apart;

said outer connecting portion being movable toward said first surface and into said cavity to a closed position by a portion of the apparatus upon mounting of the connector therein wherein said inner connecting portion is in engagement with said first circuit member, so that only when both said housing is in said first position and said terminal is in said closed position is said terminal in electrical engagement with said first circuit member thereby interconnecting said power source to said electrical unit.

20. The electrical interlock connector of claim **19** wherein said frame for said connector is disposed on a base of a module adapted to be mounted in said apparatus, said base including an aperture within walls of said frame extending therethrough and dimensioned to receive said outer connecting portion of said terminal therethrough for electrical engagement with said first apparatus portion, said module further including a cover having a further aperture dimensioned to receive said second housing surface therethrough when said connector is in the second position.

21. The electrical interlock connector of claim **20** wherein said connector housing includes shoulders extending outwardly from opposed sides thereof at a selected location against said first and second outer surfaces and substantially parallel to said first and second surfaces, said shoulders being received in corresponding slots in side walls of said frame thereby positioning said connector in said frame while allowing said housing to move between said first and second positions.

22. The electrical interlock connector of claim **21** wherein said shoulders of said connector engaging an inner surface of said cover thereby retaining said connector within said module.

23. The electrical interlock connector of claim **19** wherein said terminal includes a body and a spring section, said spring section being a U-shaped spring arm, said outer connecting portion being proximate a base of the "U" and said inner connecting portion being proximate a leading end of the spring arm.

24. An electrical interlock connector for interconnecting a power source to an electrical unit within an apparatus, said electrical connector being mountable within the apparatus against portions thereof and comprising:

an insulating housing with first and second surfaces, an electrical terminal disposed in a cavity in said housing, said terminal having an outer connecting portion and an inner connecting portion, said outer connecting portion being adapted to be electrically connected to said electrical unit; and

a first circuit member connected to said power source and attached to said housing and at least exposed within said cavity;

wherein said outer connecting portion resiliently extends outwardly of said first surface to an open position wherein said terminal and said first circuit member are electrically spaced apart;

said outer connecting portion being movable toward said first surface and into said cavity to a closed position by a portion of the apparatus upon mounting of the connector therein wherein said inner connecting portion is in engagement with said first circuit member, so that when said housing is against said first and second apparatus portions and said terminal is in said closed position said terminal is in electrical engagement with said first circuit member thereby interconnecting said power source to said electrical unit.

25. The electrical interlock connector of claim **24** wherein said terminal includes a body and a spring section, said spring section being a U-shaped spring arm, said outer connecting portion being proximate a base of the "U" and said inner connecting portion being proximate a leading end of the spring arm.

26. The electrical interlock connector of claim **25** wherein said housing further includes retention portions extending outwardly from opposite sides of a terminal-receiving body containing said terminal-receiving cavity, said retention portions being adapted to retain said connector in a desired position for connection to said electrical unit.

27. The electrical interlock connector of claim **26** wherein said retention portions extend at an angle to said terminal-receiving body and at a right angle with respect to one another such that said connector may be secured in a corner of an assembly for electrical connection to said electrical unit.

28. An electrical interlock connector for interconnecting a power source to an electrical unit within an apparatus, said electrical connector being mountable within the apparatus against portions thereof and comprising:

an insulating housing with first and second outer surfaces associated with respective portions of the apparatus;

the housing containing at least one terminal-receiving cavity having first and second portions, each portion being in communication with a corresponding one of said first and second outer surfaces;

an essentially U-shaped electrical terminal disposed in said at least one cavity and having first and second spring sections extending from a body portion, each of said first and second spring sections being disposed in a corresponding one of said first and second cavity portions, each said spring section having an outer connecting portion and an inner connecting portion, said outer connecting portion of said first spring section being adapted to be electrically connected to said electrical unit;

an insulating member mounted within the housing proximate the terminal body in a manner to permit movement from an initial position to at least one other position, said member including an elongate section having one surface that extends along said outer connecting section of said second spring section, and another surface that is adapted to engage a second apparatus portion; and

a first circuit member connected to said power source and attached to said housing;

said outer connecting portions of both said first and second spring sections resiliently extend outwardly of corresponding ones of said first and second outer surfaces to open positions wherein said terminal and said first circuit member are electrically disconnected;

said outer connecting portion of said first spring section being movable toward said first outer surface and into said first cavity portion to a closed position by a first portion of the apparatus and said outer connecting portion of said second spring section being movable toward said second outer surface and into said second cavity portion to a closed position by said insulating member upon mounting the-connector in the apparatus against said first and second portions;

whereby said inner connecting portion of said second spring section is in electrical connection with said first circuit member only when said connector is against said first portion and said second portion of the apparatus and both of said first and second spring sections of said terminal are in their closed positions thereby interconnecting said power source to said electrical unit.

29. An apparatus including first and second panels, at least one of said panels having an electrical unit thereon, said unit including first and second connecting areas at two selected locations on said at least one panel;

at least first and second panel portions associated with said first connecting area;

at least one electrical connector for interconnecting a power source to said first connecting area, said connector being mountable against said first and second panel portions, said connector including:

an insulating housing with first and second outer surfaces each associated with a corresponding one of said first and second panel portions;

the housing containing at least one terminal-receiving cavity in communication with said first outer surface;

an electrical terminal disposed in said at least one cavity and having a body portion and a spring section, said spring section having an outer connecting portion and an inner connecting portion with said outer connecting portion being adapted to be electrically connected to said first connecting area of said electrical unit; and

a first circuit member connected to said power source and attached to said housing;

said outer connecting portion resiliently extends outwardly of said first outer surface to an open position wherein said terminal and said first circuit member are electrically disconnected;

said outer connecting portion being movable toward said first outer surface and into said cavity to a closed position by said first panel portion upon mounting the connector in the apparatus against said first and second panel portions, said connector having a section along said second outer surface that engages said second panel portion, said connector section being remote from and relatively movable with respect to said spring section;

whereby said inner connecting portion is at least in electrical connection with said first circuit member only when said connector is against said first and second panel portions and said terminal is in its closed position thereby interconnecting said power source to said first connecting area of said electrical unit; and

a second circuit member connected to said power source and electrically engaged by an interconnecting element to said second connecting area on said at least one panel of said apparatus thereby completing an electrical circuit and interconnecting said power source to said electrical unit.

30. The apparatus of claim **29** wherein said interconnecting element is another electrical terminal.

31. The apparatus of claim **29** wherein said connector section of said at least one connector includes:

a second terminal that is disengaged from said first circuit member unless biased by said second panel portion, said second terminal being disposed in a second terminal-receiving cavity in said housing, said second terminal having a body portion and a spring section including an outer connecting section and an inner connecting section such that upon biasing said second terminal said inner connecting section thereof engages the first circuit member and concomitantly therewith said first apparatus portion moves the inner connecting portion of the terminal in said at least one cavity into electrical engagement with the body of the second terminal thereby effecting interconnection between said power source and said electrical unit.

32. The apparatus of claim **29** wherein said connector section of said at least one connector is an insulating member that is biased by said second apparatus portion such that a second spring section of the terminal engages said circuit member, said insulating member being mounted within said housing proximate said terminal in a manner to permit movement from an initial position to at least one other position, the second spring section having an outer connecting portion resiliently extending outwardly of the second outer surface of the housing and an inner connecting portion that is adapted to electrically engage the first circuit member upon being moved by the insulating member to its closed position.

33. The apparatus of claim **29** wherein said wherein said first and second panels are glass.

34. The apparatus of claim **29** further including a sensing module adapted to determine when said power source is to be activated.

35. The apparatus of claim **29** wherein said interconnecting element is a second connector mounted to said apparatus against third and fourth panel portions.

36. The apparatus of claim **33** wherein said second connector includes:

an insulating housing with first and second outer surfaces each associated with a corresponding one of said third and fourth panel portions;

the housing containing at least one terminal-receiving cavity in communication with said first outer surface; and

an electrical terminal disposed in said at least one cavity and having a body portion and a spring section, said spring section having an outer connecting portion and an inner connecting portion with said outer connecting portion being adapted to be electrically connected to said second connecting area of said electrical unit;

said second circuit member being attached to said housing;

said outer connecting portion resiliently extends outwardly of said first outer surface to an open position wherein said terminal and said second circuit member are electrically disconnected;

said outer connecting portion being movable toward said first outer surface and into said cavity to a closed position by said first panel portion upon mounting the connector in the apparatus against said third and fourth panel portions, said connector having a section along said second outer surface that engages said fourth panel portion, said connector section being remote from and relatively movable with respect to said spring section,

whereby said inner connecting portion is at least in electrical connection with said second circuit member only when said connector is against said third and fourth panel portions and said terminal is in its closed position thereby interconnecting said power source to said second connecting area of said electrical unit.

37. The apparatus of claim **29** wherein said connector section of said at least one connector is the second outer surface of said housing, said second surface being in engagement with said second panel portion when the connector is mounted in the apparatus.

38. The apparatus of claim **37** wherein said connector is disposed in and is freely slidable within a frame in a direction perpendicular to the first outer surface from a first position to a second position, such that the outer connecting portion of the terminal is moved to the closed position and the inner connecting portion thereof is brought into engagement with the first circuit member.

39. The apparatus of claim **29** wherein said wherein said first and second panels are opposed to one another.

40. The apparatus of claim **39** further including a sensing module adapted to determine when said power source is to be activated.

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